A CRITICAL REVISION OF THE GENUS EUCALYPTUS

BY

J. H. MAIDEN, I.S.O., F.R.S., F.L.S.

(Government Botanist of New South Wales and Director of the Botanic Gardens, Sydney).

VOL. VI. PART 2.

PART LII OF THE COMPLETE WORK.

(WITH FOUR PLATES.)

PRICE THREE SHILLINGS AND SIXPENCE.

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"Ages are spent in collecting materials, ages more in separating and combining them. Even when a system has been formed, there is still something to add, to alter, or to reject. Every generation enjoys the use of a vast hoard bequeathed to it by antiquity, and transmits that hoard, augmented by fresh acquisitions, to future ages. In these pursuits, therefore, the first speculators lie under great disadvantages, and even when they fail, are entitled to praise."

MACAULAY'S "ESSAY ON MILTON."

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HYBRIDISATION IN THE GENUS.

No. II. The Bark.

(Continued from Part LI, p. 59.)

HYBRIDISATION IN THE GENUS.

A.—HISTORICAL.

The following notes are given, as far as convenient, in chronological order :—

Caley (1800–1810).—In *Agric. Gaz., N.S.W.*, xiv, p. 988, October, 1903, I have an article " George Caley, Botanical Collector in New South Wales, 1800–1810," which contains determinations of Eucalypts based on some of Caley's specimens in the Vienna Herbarium. At p. 990 it is recorded that Caley gives the name " Burryagro—A hybrid between Barilgora and Derrobarry "—to the species *E. Boormani* Deane and Maiden, which (*Proc. Linn. Soc., N.S.W.*, xxvi, 339, 1901), we had expressed the opinion might be a hybrid, although in ignorance that Caley had expressed a similar opinion nearly a century before. Now " Barilgora " was the aboriginal name for *E. hemiphloia* F.v.M. and " Derrobarry " for *E. siderophloia* Benth.

The blacks had but one name for *E. Boormani* and for *E. siderophloia* ; but Caley saw they were different, and his surmise as to hybridisation was marvellously shrewd. He was undoubtedly the discoverer of hybridisation in this genus. He studied the trees in the bush, made his pronouncement, and produced his specimens to back up his statement. Compare also, in connection with *E. Boormani* (*Proc. Linn. Soc., N.S.W.*, xxv, 339, 1901; *op. cit.*, xxx, 494, 1905).

In my work, " Sir Joseph Banks, the Father of Australia," p. 140, I say— " Recently I dedicated a New England Ironbark, *Eucalyptus Caleyi*, to his memory, to remind botanists of his discovery of hybridisation in the genus, in which he showed an Ironbark to take a part."

I followed up my *Agric. Gazette* paper (1903) by what may be termed a manifesto conveying whole-hearted belief in hybridisation in the genus. This was a paper in *Rep. Aust. Assoc. Adv. Science*, vol. x, pp. 297–303, 1904, which was translated into French, and published in *Rév. Hort. de l'Algérie*, Sept., 1905, pp. 211–216.

Bentham, 1863.—In his preface to vol. I of the " Flora Australiensis," p. 17, Bentham, not specially referring to Eucalyptus, remarks :—

> Little as we know, for instance, of the influence of natural hybridising in Europe, it has been still less, if ever, observed in Australia; and many other causes may have produced apparent passages between species really distinct. I have, therefore, whenever there is a difference of opinion between Dr. Mueller and myself, adopted the conclusion which has appeared to me the most probable, and mentioned the objection to it for the consideration and, if possible, the decision of future botanists.

The best known Australian case of description of a non-Eucalyptus hybrid as a species is that of *Brachychiton populneo-acerifolium* F.v.M., in *Journ. Linn. Soc., N.S.W.*, ix, 379 (1884).

Woolls, 1867.—The late Rev. Dr. Woolls refers to the subject:—

> Even in the Grey Gum or Hybrid Box (*E. tereticornis*), which appears more subject to variation than any Gum in New South Wales, there is sufficient uniformity in the seed-vessel to mark the species. The leaves are subject to great diversity. . . . It is in this Gum that workmen speak so much of hybridisation, as they imagine that the flowers of the Grey Gum are sometimes inoculated by the pollen of the Box, so that an intermediate variety springs up. . . . My own impression is that the varieties of the Grey Gum, to whatever causes they may be due, are not transmissible from generation to generation, and that they do not extend beyond the individuals so circumstanced; whilst I regard one of the kinds at least which workmen consider hybrid as a true species, for it has a uniform seed-vessel of its own, and prevails to too great an extent to admit of the supposition that it is the result of fortuitous impregnation. ("A Contribution to the Flora of Australia," pp. 219–20.)

The above remarks were published in 1867, and as the author died in 1893 it is obviously unfair to quote him as a non-believer in hybridisation in Eucalyptus. I do not, however, know any published statement of his in which he expressed different views, and at least up to within a few years of his death he leaned to his views of 1867. (Maiden in *Report Aust. Assoc. Adv. Science*, 1904, p. 298.) In future this reference will be given as Maiden, 1904.

The following passage: "If nature does not admit of crossing in the genus Eucalyptus . . ." (Woolls in *Proc. Linn. Soc. N.S.W.*, xvi, 61, 1891), shows that he remained in doubt on the general question of hybridism in the genus.

Mueller, 1880–1890.—Mueller always seemed to fight shy of the question, both in conversation and in his writings. Here follow two observations from his pen:—

> Also in the particular series of Eucalyptus species to which *E. Foelschiana* belongs, some forms occur, the originals of which may possibly be traceable to hybridism, notwithstanding that in this genus the contact of the anthers with the stigma commences already, while stamens and pistils are still covered by the lid, &c. ("Eucalyptographia," under *E. Foelschiana*.)

Again:—

> On the summit of Mount Wellington I collected a state of *E urnigera*, with all leaves nearly oval and with simply truncate-ovate fruits. Hybridism does not seem to explain the origin of these aberrant forms in a genus, where cross fertilisation is guarded against by a calycine lid, though, as pointed out by Mr. W. Sh. Macleay, the possibility of such a process is thereby not absolutely excluded, as parrots, &c ("Eucalyptographia" under *E. cordata*.) (Maiden, 1904, p. 299.)

This reference to Mr. W. S. Macleay probably originated with Rev. Dr. Woolls, see below, p. 69.

Mueller published, without comment, in 1889, a statement that Mr. W. Baeuerlen had sent from near the Clyde, New South Wales, "Specimens of an Eucalypt which he considers a hybrid between *E. corymbosa* and *E. maculata*, in which case the characteristics of the former are prevailing." He then goes on to describe some of the points in which the specimens in question partake of the character of the two species referred to. "Mr. Baeuerlen was then, as now, Collector for the Technological Museum at Sydney the botanical collections of which were founded by me. It is only proper to say that Mr. Baeuerlen was, during the period that he served under me, a consistent advocate for recognition of the principle of hybridism in Eucalypts. In taking up the position I do now, of freely recognising the principle, I bear testimony to the fact that

Mr. Baeuerlen, in correspondence with me, confidently asserted it at a time when I felt myself unable to definitely commit myself to an opinion without further evidence than I then possessed." (Maiden, 1904, p. 302.)

It is not easy for the present generation to understand the position of the younger botanists in the earlier eighties, in regard to Mueller's attitude concerning hybridisation. He had been writing on Eucalypts for thirty years, had described many new species, was the assistant of Bentham in regard to the "Flora Australiensis," was the author of "Eucalyptographia," but was most sensitive to what he termed "opposition," or, as we would call it nowadays, "free inquiry." He was most autocratic, and had founded and was in charge of the Melbourne Herbarium, in which were thousands of types and critical plants. When one day in October, 1885, I broached the subject to him in his private house, I was a little surprised at the vehemence with which he told me he almost did not believe in hybridisation in the genus, and then read me a homily on loyalty, *i.e.*, the impropriety of holding opinions different to his own. This interview had the effect of causing me to drop the subject, at all events within the hearing of Australia's benevolent botanical autocrat.

Naudin, 1883.—The late M. Charles Naudin, of Antibes, southern France, distinguished both for his researches on hybridisation in plants and for work on the cultivated forms of Eucalyptus, was a correspondent of Mueller, and he distinctly states ("Mémoire sur les Eucalyptus introduits dans la Région Méditerranéenne," *Ann. des Sciences Naturelles*, 6e série, Bot. t. xxv, 337–430 (1883), p. 355 (quoted by me as "1st Mem.") that the latter does not believe in hybridisation in Eucalyptus :—

> M. le baron Müller ne croit pas à l'hybridation dans les Eucalyptus, cependant il existe des formes si parfaitement intermédiaires entre des espèces acceptéés par tous les botanistes, qu'on ne peut guère douter qu'il ne s'y forme des hybrides, comme dans tant d'autres genres, les Saules et les Rosiers par exemple. (Maiden, 1904, p. 299.)

My readers are invited to peruse more extended notices of the work of Naudin and Trabut from my paper in question, pp. 299–300, in the direction of promoting a knowledge of hybridisation in the genus.

It is, indeed, to the French that we owe full statements in regard to the question. Cordier was the pioneer amongst these; Naudin later on adduced valuable evidence, and demonstrated it, while Trabut submitted overwhelming evidence. The French botanists planted long lines of Eucalypts in Algeria, and as they grew, flowered and fruited and shed seed, it became easy to see, when their progeny flowered and fruited, that some of them possessed obvious intermediate characters derived from their parents alongside. When I saw buds and fruits of *E. gomphocornuta* from trees adjacent to *E. gomphocephala* and *E. cornuta*, and noticed their intermediate character, the last trace of doubt as to hybridisation in the genus passed from my mind. Having quoted Naudin briefly, let me quote Trabut, who gives a condensed historical sketch.

Trabut, 1917.—Dr. L. Trabut, *Bull. de la Station de Recherches Forestières Nord de l'Afrique* (Alger), tome i, p. 140 (1917). The paper contains an admirable *résumé* of the history of the work of French botanists.

Following is a translation, from which it would appear that M. Cordier was the rediscoverer of hybridism in the genus, and first gave it importance :—

Eucalypts were introduced into France about 1854, and since 1862 several plantations have been made in Algiers, notably at the Jardin d'Essai. About this time, Ramel, who studied the works of Mueller, of Australia, was the apostle of Eucalyptus in Algiers. Trottier[1] and Cordier not only planted *E. globulus*, but established collections of numerous species, with the view to a comparative study.

The collection of Cordier, a former President of the Botanical Society of France, established on the estate of El Alia à Maison-Carree, was begun in 1864. In 1876 it amounted to 10,000 trees. An equal number had been planted by Cordier at his estate of Hadjadjs at Reghaia. Cordier received the seeds of 130 species, and, in 1876, 120 species more or less prospered at El Alia. The determinations were not rigorous, and under the same name very different forms occurred, and, under different names, there were representatives of the same species.

Cordier, desirous of giving precision to his studies, appealed to botanists who had given attention to this genus, and I have had occasion to repeatedly go through the Cordier collections with Naudin and H. de Vilmorin. A certain number of plants difficult to determine resulted from sowings made with seeds collected on the estate, seed which were largely distributed to horticulturists and amateurs.

Hybridisation.—Cordier thought that the multiplicity of variations indicated hybridisation, and made the observation that the indeterminate plants grew more vigorously. At this time the role of hybridisation in the multiplicity of forms of Eucalyptus was not admitted, Mueller being categorically against it. Meanwhile Naudin, who had devoted to the study of hybridisation a good portion of his scientific career, did not hesitate to admit the ideas of Cordier, an observer who was without prejudices in the matter.

(Here follows descriptions of a number of hybrid species, reproduced below, beginning with *E. Trabuti*, see p. 79).

Like a certain number of genera well known by the multiplicity of their forms, and the uncertain limits between the groupings named as species, the genus Eucalyptus offers to descriptive botanists an opportunity for exercising their perspicacity in the finding out and appraisement of characters said to be specific.

Without wishing to prejudge what may happen in Australia, I do not hesitate to state that with us (Algiers) the introduced Eucalypts, brought together in our collections, cross with the greatest facility, and this results in the variation that Naudin called "desordonnée" (irregular).

The several hybrids that I have indicated at a time when specialists in Eucalyptus denied the existence, and even the possibility of hybridisation in the species, are only isolated cases fortuitously observed; methodical search will reveal a much larger number.

Besides the scientific interest that this verification presents, it has an important practical interest, for some hybrid species, already under observation for twenty years, are more vigorous and better adapted to our country than their parents. It is incontestable with these hybrids that they will constitute wooded areas which will one day relieve us from a large importation of wood and fuel from abroad.

Under the influence of cultivation there is also produced, very likely, variations that one would not be able to attribute with certainty to a recent crossing.

It may be objected, perhaps, that in the genus Eucalyptus species may produce themselves by mutation. But it will always be very difficult to eliminate from the causes of these mutations the action of a foreign pollen.

There remains now to practice artificial hybridisation. I am convinced that the scientific and practical results of it would be considerable. The raising of Eucalypts (Eucalyptus breeding) is important for the Mediterranean region, where this tree should render most important services.

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[1] See Trottier—De l'accroissement et de la valeur progressive de l'Eucalyptus. Alger, 1871. 8 vo.
See also my "Forest Flora of New South Wales," Part LXVIII, p. 374.

Kinney, 1895.—Abbot Kinney ("Eucalyptus," Los Angeles, Cal., p. 23, 1895), says :—

Mr. L. Stengel, an experienced and careful nurseryman, is of opinion that Eucalyptus has a strong tendency to hybridise. He then refers to certain seedlings obtained from a sowing of reputed *E. robusta* seed :—"The vast majority were true to the parent tree. . . . One specimen was identical with *globulus*, several were like *amygdalina* var. *regnans;* in fact, about fifteen distinct species apparently came from these *robusta* seed." This is not evidence of hybridisation, but of mixed seed; at the same time I have seen Californian specimens which, in my opinion, indicate hybridisation. (Maiden, 1904, p. 303.)

Cambage, 1900.—R. H. Cambage :—

In view of the prominence given to the question of hybridisation of Eucalypts by Messrs. Deane and Maiden in the *Proc. Linn. Soc.*, vol. xxv, p. 111, where they deal with *E. affinis*, which grows among *E. sideroxylon* and *E. albens*, also with another tree growing among *E. siderophloia* and *E. hemiphloia* at Homebush and Liverpool, it occurred to me that if cross-fertilisation exists between the above trees, the same sort of thing may take place in other species, notably between *E. sideroxylon* and the western Box tree recently described by Mr. R. T. Baker as *E. Woollsiana*. Knowing that I should meet with these two species growing together in several places, I decided to make diligent search for trees which would answer the required conditions of hybrids. After coming into the Ironbarks and Box a few hundred yards, these trees were found which seem intermediate in every respect between *E. sideroxylon* and *E. Woollsiana* both in the colour and texture of the bark and wood, as well as in the size of the fruits, which are larger than those of *E. Woollsiana*, but smaller than those of *E. sideroxylon*. This doubtful looking tree was found again several times before reaching the Lachlan, but never in great numbers, and invariably associated with the same two species. These are points of circumstancial evidence which suggest hybridisation.

He proceeds to discuss the flowering periods of Eucalypts in relation to hybridisation, a subject touched upon somewhat casually by the Rev. Dr. Woolls some years before (*Proc. Linn. Soc. N.S.W.*, xxv, p. 716).

Cambage, 1901.—Reference to a supposed hybrid box in the Condobolin district (*E. sideroxylon* x *E. Woollsiana*) (*ib.*, xxvi, 324).

A supposed hybrid between *E. sideroxylon* and *E. hemiphloia* var. *albens*, and discussion of *E. affinis* Deane and Maiden, a reputed hybrid, and which Mr. Cambage stated had been under his notice for about ten years (p. 691).

Cambage, 1902.—A supposed hybrid between *E. sideroxylon* and *E. Woollsiana* at Barmedman (*ib.*, xxvii, 195).

Baker and *Smith*, 1902.—Messrs. Baker and Smith, "Research on the Eucalypts," p. 15 (1902), under the heading "Hybridisation," say :—

Some attention has been given to this subject, but so far without any measure of success, as it appears difficult to understand how natural hybridisation pertains in the origin of Eucalyptus species, the essential organs being protected by an operculum, and in almost every instance pollen grains are found adhering to stigmas before the operculum falls off.

Baron von Mueller at one time did not regard hybridisation as impossible, but thought that all ordiary chances are against it, for he states "Hybridism does not seem to explain the origin of these aberrant forms (this investigation shows that most of these supposed aberrant forms are really distinct species) in a genus, where cross-fertilisation is guarded by a calcyine lid." ("Eucalyptographia," under *E. cordata.*)

Of course, the opening of the flower serves some purpose in nature, and no doubt insects and other agencies assist or contribute in cross-fertilisation in very rare cases, but in such instances the possible sterility of these hybrids must be taken into consideration.

Cross-fertilisation in the case of eucalypts is, in our opinion, quite exceptional, especially when we know at this present time that millions of these trees are growing intermixed, and although often flowering at the same time, yet preserve throughout extensive ranges their specific characters with remarkable constancy.

Maiden, 1903, 1904.—I have already referred to my papers on hybridisation under these dates.

See also my paper "Further Notes on Hybridisation in the genus Eucalyptus" (*Proc. Linn. Soc., N.S.W.*, xxx, 492, 1905) which contains specific instances attributed to this phenomenon, also "On a Eucalypt Hybrid (*E. calophylla* x *E. ficifolia*)," (*ib.* xli, 185, 1916). I have published other brief notes on hybridism in the present and other works.

Hall, 1912.—

In considering the question of hybridisation between Eucalypts, full consideration should always be given to the time of the year at which they flower. Thus, crossing of *E. robusta*, which blooms in winter, with *E. hemiphloia*, which is out in summer, would be impossible, though there is a chance of such crossing occurring between *E. tereticornis* and *E. paniculata*, or *E. saligna* and *E. acmenioides*. But the mere fact of two species growing together and flowering at the same time, yet maintaining constant and specific characteristics over a great range, points to the conclusion that hybridisation is most unlikely or impossible between them. In fact, I think the law may be laid down, that natural hybridisation is unlikely to occur between two species growing freely together and flowering at the same time. If I were attempting to hybridise Eucalypts, I should expect greater chances of success from two species growing widely apart, as say from Western and Eastern Australia, than from two growing together and blooming simultaneously. (Cuthbert Hall, *Proc. Linn. Soc. N.S.W.*, xxxvii, 566, 1912.)

See also Dr. Trabut's remarks, written in 1904, quoted at p. 73, below.

Hall, 1914.—

Again as to hybridism, I have been keenly on the alert to discover instances of this, but, after examining thousands of seedlings from different species, I have not seen one single instance of it so far. Although the seedlings of many species differ so markedly from one another, that they could be detected at once, I have hitherto found them uniform throughout, though there may be slight differences in size, vigour, &c. Still, knowing that hybridism has actually been proved in the genus *Acacia* (*Proc. Linn. Soc. N.S.W.*, xxxv, Part II), of which, as of the Eucalypts, so many species occur in Australia, we may hope soon for actual demonstration of such occurring in the latter. Up to the present, though much has been said as to one species being a hybrid of two others, we have had no actual proof. (Cuthbert Hall, *Proc. Linn. Soc. N.S.W.*, xxxix, 475, 1914.)

At the same time Dr. Hall, in his description of *E. Marsdeni* (*Proc. Linn. Soc. N.S.W.*, xliii, 747, 1918) shows that he does not exclude the role of hybridisation in the genus.

Maiden, 1914.—I give copy of an extract ("Hybridism in the Genus") from a paper I read before the British Association for the Advancement of Science at its Sydney meeting in August, 1914, and a paper by Mr. Cambage and myself entitled "Observations on some reputed Natural Eucalyptus Hybrids" (*Journ. Roy. Soc. N.S.W.*, xlviii, 415, 1914), may be turned to.

Hybridism in the genus.—The most convincing illustrations of hybridism in Eucalyptus (which is not very obvious as a rule, and hence has been denied), to me personally were afforded by a Eucalyptus plantation in Algeria, where intermediate forms of planted species displaying pronounced morphological characters were obtained from spontaneous seedling trees. We rarely cultivate Eucalypts in Australia on a large scale, and some of the exceptions are the plantations at Wirrabara and other places under the direction of the Conservator of Forests of South Australia. Study of these plantations would doubtless afford valuable data in regard to the evolution of new forms.

Hybridisation in wild species has apparently not been much investigated in any part of the world[1]. As regards Eucalyptus I have brought together a considerable number of facts[2] bearing on the subject, and have referred to the matter from time to time in my "Critical Revision of the genus Eucalyptus," and other works. As in Australia the evidence as to Eucalyptus hybrids is mainly based on inference, it appeared to me best, when I shall have cleared the ground by a critical examination of each species, to devote some parts of that work to consideration of the question of hybridisation alone, since, in my view, pictorial illustration is necessary to a proper understanding of it.

I am redeeming my promise in the present and following Part.

Perez, 1919 *et ante.*—The late Dr. G. V. Perez was for a number of years a firm believer in hybridisation in the genus. See under *E. ficifolia* x *calophylla* at p. 281, Part XLIX of the present work.

Baker and *Smith*, 1920.—In "Research on the Eucalypts," 2nd edition, p. 13, there is a note headed "Hybridisation." On reading this page, it is difficult to understand whether Mr. Baker believes that hybridisation occurs in the genus under natural conditions. At all events, the admission, if made, is done very grudgingly. I do not complain of the exercise of caution in the matter, for, as a botanist who has perhaps given more attention to the subject than any other Australian worker, I freely admit that the subject is full of pitfalls, which particularly beset those who have not endeavoured to view it from every direction that presents itself. At the same time much evidence has been available for a good many years now.

B.—BIRDS AND FERTILISATION.

Here is an appropriate place to refer to the remarks of A. G. Hamilton, one of the most distinguished of Australian workers on fertilisation. I quote from two of his presidential addresses before the Linnean Society of New South Wales, as contained in the Journals of the Society. The whole of the addresses should be read.

Little that is definite is on record about the pollination of *Eucalyptus*, or, with one exception, of *Acacia*. I looked up both orders in Hermann Muller's and Knuth's books, and was greatly astonished to find that neither book has any reference at all to the Myrtaceæ. The order seems to have been passed over by inquirers into pollination methods. And very few observations are recorded on *Acacia*. In the case of *Eucalyptus*, we know that the flowers are visited by the brush-tongued lories and by some of the honey-eaters. In a paper by Mr. Swinnerton "On Short Cuts by Birds to Nectaries" (*Journ. Linn. Soc.* (Bot.), vol. xliii), being observations made in South Africa, he mentions *E. ficifolia* as being visited by Sunbirds, and also by other birds, as well as insects. He believes that in South Africa this species is chiefly

[1] "Hybridisation of Wild Plants." D. T. MacDougal, *Bot. Gaz.* xliii, 45 (1907).

[2] "On Hybridisation in the genus Eucalyptus," *Proc. Aust. Ass. Adv. Science* x, 297 (1904); *Proc. Linn. Soc., N.S.W.*, xxx, 492 (1905); *Pro. Roy. Soc., N.S.W.*, xlvii, 233, (1913).

pollinated by hive bees and Sphingidæ. The Eucalyptus flower being of a shallow, open type, with much nectar, it seems rather extraordinary that it should be pollinated by Sphinges. The lories, having a short tongue, are certainly well adapted for the work, but I should have thought that slender-billed birds and long-tongued moths would not be likely to pollinate the flowers.

Nowadays, introduced hive-bees are usually the most conspicuous visitors, both to garden plants, and, in localities not too remote from settlement, also to native plants, including Eucalypts, Banksias, and Grevilleas. Bee-keepers are glad to have Eucalypt forest in proximity to their apiaries. In some cases, doubtless, the hive-bees are instrumental in effecting pollination. But in others they merely deprive the flower-frequenting birds of their birthright, without accomplishing anything for the benefit of the plants. (Vol. xlii, p. 14, 1917.)

The profession of pollinator seems in the main to be confined to a few families of birds. In America the humming-birds (*Trochilidae*) and sugar-birds (*Coerebidae*) are chiefly concerned. In Hawaii the *Drepanididae* (35 spp. in 17 genera) and *Meliphagidae* (5 spp. in 2 genera) are the agents. In Australia we have *Meliphagidae* (72 spp. in 23 genera) and seven species of brush-tongued Lorikeets. Africa has its Sunbirds (*Cinnyridae*) and Flower-peekers (*Dicaeidae*). In New Zealand are the *Meliphagidae* and a few parrots. But there is no doubt that other birds at times pollinate flowers. Whether they visit the flowers in search of insects or nectar is not quite apparent. (xli, 18, 1916.)

A correspondent, Mr. S. T. Turner, in a letter mentions that at the time of writing parrots were very busy biting off the opercula of Eucalypt-buds. (p. 26.)

I have already alluded to the want of systematic observations on the method of pollination in Acacia and Eucalyptus. It is a very lamentable thing that no one has taken these genera up. Here we have two very large, and, from either the scientific or the economic points of view, very important and characteristic genera, and yet no one seems to have attempted to solve these important problems. Certainly some observations have been made in America and South Africa, but it is obvious that these are of little value from an Australian point of view. The agents of pollination are not the same, though of course we may get suggestive hints which will assist the local worker when he arrives. (*ib.*, p. 21.)

Now we come to some observations by a well-known Western Australian worker :—

Species of Eucalyptus come next on my list. Sepals and petals are discarded at anthesis in the form of a calyptra (operculum) in this genus, and the open blossom is in some respects very simple in structure. A ring of numerous thread-like stamens surrounds the top of the ovary, which is surmounted by a slender terete style, whose apex is stigmatic. A few figures recently obtained from a flower of *Eucalyptus macrocarpa* Hook., will be much more effective than a long description in revealing the character of the flowers. I estimated the number of stamens at 1,400. Their bases occupied a band round the ovary top 2½ mm. wide, while their anther-bearing tops spread to a width of about 25 mm. The middle circumference of the stamen ring taken over the anthers was 140 mm. The stigma was less than a millimetre in diameter! The area of the pollen-*bearing* surface was therefore over 3,000 times the area of the surface adapted for *receiving* pollen. In this estimate I have included the spaces between the anthers; but even if that inclusion be disallowed, the ratio would still be enormously disproportionate. What could be more eloquent of the low degree of specialisation of this flower? I have no positive knowledge that birds are the chosen agents of pollination in this particular species, but I feel no doubt whatever such is the case. While the above is perhaps an extreme case in all species of Eucalyptus, the area of the pollen-bearing surface is enormously out of proportion to the area of the stigma, which is always minute. This points, I think, to a pollinator of comparatively large size. The top of the ovary secretes nectar, often very copiously, so that it falls in drops from the flowers. Birds seeking this nectar would certainly be liberally dusted with pollen, and could scarcely fail to bring some of their pollen-bearing feathers into contact with the stigma. I have many times seen small parakeets busy on the flowers of *E. reduncа Schau.*, and *E. accedens W. V. Fitz.* Once I observed *Zosterops gouldi* sipping nectar from the flowers of *E. loxophleba* Benth. The only species I have observed at all closely is *E. calophylla* R.Br. Its flowers are freely visited by insects seeking the very copious nectar or pollen. Various honey-eating birds are also frequent visitors. The latter appear to be efficient pollinators; but the insects seem useless. I have never seen one brush against a stigma, though I have

watched long and carefully. I have found Eucalypts troublesome to observe, and I regard my present knowledge of their flower biology as very incomplete. Yet, what I have so far seen has impressed upon me the belief that birds are the chief pollinators of the genus. The small size of some of the flowers at first led me to regard them as entomophilous, but I am now satisfied that birds could and would take nectar from the smallest, and in so doing would almost certainly effect pollination. (O. H. Sargent in "Annals of Botany," vol. xxxii, pp. 217–218, 1918.)

The zoologist, W. Sharpe Macleay, early in the last century, remarked (Woolls, "A Contribution to the Flora of Australia," 1867, p. 219) "that parrots and other birds occasionally bite off the flower buds, and may accidentally uncover a stigma and remove the anthers; and, again, insects may then finish off their work and carry pollen across from another species."

After consultuation with Mr. J. J. Fletcher, editor of the Macleay Memorial Volume (Linnean Society of New South Wales, 1893), which contains an account of Mr. W. Sharpe Macleay's work, and careful search by him of the latter's papers, he says that he is satisfied that Mr. Macleay's observation, to which Rev. Dr. Woolls refers, was contained in a private letter or a verbal communication.

The Australian Museum Catalogue of birds (A. J. North) dealing with the *Meliphagidæ*, and the Brush-tongued Lorikeets, give lists of honey-eating birds so far as Australian species are concerned.

A list of Australian insects found on *Angophora cordifolia* during December, 1912, at Como, will be found in *Aust. Naturalist*, vol. iii, p. 18 (1914). They may be captured on Eucalyptus also. A list of honey-eating insects of Australia would comprise approximately half the described species. Reference may also be made to the insects which frequent Eucalyptus in Parts 65 and 66 of my "Forest Flora of New South Wales."

A. G. Hamilton makes the following observation, and I think it is concurred in by the majority of Australian observers :—

I do not think that there is any foundation for the opinion that Eucalypt-flowers are fertilised in the bud. They are conspicuous flowers when open, scented, and contain a large amount of nectar, all of which would point to pollination by insects or birds. (*ib.* xli, p. 26.)

Anyone who will examine a number of Eucalyptus flowers of any species freshly opened will see that in the vast majority the stigma is quite free and clear of any pollen, while all the anther cells (the pollen vessels) are still closed, so much so that one often has to look for other flowers in order to find out the anther group to which these particular anthers belong. A number have the filaments so much incurved when the flowers open, that it is practically impossible in that position for the anthers to come into contact with the stigma, and even if they did, it would not cause fertilisation at that stage, since the pollen is still enclosed, and it is the *free pollen*, and *not the anthers* that ensure fertilisation. So much is clear to my mind; the proof some require is as to whether fertilisation takes place before the throwing off of the operculum. I doubt it.

There are differences in the styles as regards length, some being well protruded beyond the stamens. The stigma also may be punctiform; on the other hand it may be more or less capitate or dilated. The stigma may be protected by fitting, as if moulded, into the top of the operculum. In other words, the operculum may act as a sheath to the stigma. This is readily seen in species with large flower-buds such as *E. pyriformis* and *E. macrocarpa*. I will return to the subject when dealing with the organs concerned.

C.—HYBRIDS AND ABERRANT FORMS.

The hybrids already and to be described are interesting for the reason that they may be assumed to be incipient species, and their history will be watched in the future.

I look upon these hybrids as subordinate species, and I would gladly give them names to indicate inferiority (in botanical rank) to the ordinary species. But it seems to me that I have no choice between naming them like ordinary species, or continuing to refer to them by circumlocution, which is in the highest degree inconvenient.

One must not rely too much on the plates, in this and the next Part, which, of course, can only display morphological characters. One must consider the other characters referred to in the text, and, indeed, on consideration of these, the botanist who suggests hybridism as an explanation, has pointed out the differences from the species he considers it most closely to resemble, and yet to substantially depart from.

There are pitfalls in assuming a species may be a hybrid, *e.g.*, *E. amplifolia* Naudin. In this case a plant showed characters sufficiently different from *E. tereticornis* for Naudin to note an undescribed species. He made the natural mistake, however, to attribute the differences to hybridisation, when, as a matter of fact, his French Algerian plants arose from seeds of Australian plants sent as *E. tereticornis*.

There is another aspect of the question of the ever-varying morphological aspect of a species. Variation in Eucalyptus (and, indeed, all other genera) is going on all around us. I have in mind coming across in a *E. saligna* area a tree with very rough flaky, exfoliating bark, similar to that which is usually seen to but a very small extent on the butts of trees of that species. The buds and fruits seemed to be similar to those of the rest of the *salignas* about. But might it not have been that the tree was under the influence of saline conditions of soil? We know that *E. botryoides*, which sometimes has the organs so similar to those of *E. saligna*, that we say they "run" into each other, that is to say, it is very difficult and perhaps impossible to separate them on morphological grounds, and it is a rough-barked species and often grows in soil more or less saline. Perhaps this rough-barked *saligna* is evolving into *botryoides*, and that the rough, exfoliating bark is an expression of intolerance to salinity.

A perfectly smooth gum of any species is an ideal; indeed, what we call "typical" barks of any class are ideals; they vary, and we try to explain the variation, and, when the variation has proceeded far, we cut the knot, and constitute a new species.

A valuable historical review, entitled "The Founders of the Art of Breeding," by Herbert F. Roberts, will be found in *Journal of Heredity*, x, 99, 147 (March and April 1919).

After giving due credit to Koelreuter and others for their pioneer work in regard to sexuality in plants, he draws attention to what he terms "the revelations of Sprengel," who published (in German) his work "The Newly Revealed Secret of Nature in the Structure and Fertilisation of Flowers" (Berlin, 1793). It was Sprengel's chief merit to discover the fact of insect fertilisation. Roberts goes on to say that to Sprengel we owe the discovery of dichogamy, *i.e.*, the maturing of the stamens and pistils of flowers at different times. His conclusion that Nature, in most cases, intended that flowers should not be fertilised by their own pollen, and that the peculiarities of flower structure can only be understood when studied in relation to the insect world were revolutionary for his time. Roberts proceeds to point out that it remained for Darwin to show how the results from such perpetual crossings are limited and held in check by the operation of natural selection. And not long afterwards (though neglected for a generation) came the work of Mendel, and then the scientific age of plant-breeding and the development of "genetics."

Dr. D. T. MacDougall's paper ("Hybridisation of Wild Plants," *Bot. Gaz.*, lxiii, 45, 1907) begins—

> The number of forms of plants which have been or are regarded as hybrids by systematists is a large one and includes several oaks, of which two have been examined during the last two seasons. Attention has been called previously to the untrustworthiness of the custom prevalent among botanists of attributing a hybrid origin to certain plants because they appear to exhibit halved, fused characters, or a mosaic of qualities derived from the two supposititious ancestors. In some instances such deductions have been made by which the ancestry of a questionable plant has been made to include three or even four species. The argument of distribution is the main one offered in such attempted demonstrations. In many cases this, together with other circumstantial evidence, may amount to almost positive conviction, but unless this close relation of well-joined facts is furnished, assertions as to the hybridity of a plant must be taken simply as a suggestion to be tested by cultural or experimental methods.

He points out—

> The reformation of a hybrid by the cross-pollination of the parents to which it may be ascribed is by no means simple in all instances, nor is it always easy of accomplishment. In the first place, the original cross-pollination may have taken place possibly under an exceedingly rare combination of favourable physiological conditions difficult to secure or duplicate in experimentation.

Dr. MacDougal's own experiments to illustrate his paper are based on *Quercus*, and it concludes with references to a large number of natural plant hybrids of North America, based on a list originally prepared by Dr. David George. It takes cognisance of 117 hybrids distributed over twenty-four families. The paper is most suggestive.

See also A. R. Rolfe's remarks on hybridisation in Orchids (*Orchid Review*, 1916, 1917).

> Although the number of artificially produced hybrid trees is small, compared to the number of crosses among other species, several noteworthy trees have been described from time to time which do not conform to any known kinds, and they have been attributed to an assumed hybrid ancestry.

Then follows a select list of trees which "have been regarded upon reasonably good evidence as natural hybrids." The whole paper, on a Hybrid Catalpa is well worth study. (Jones and Filley in *Journal of Heredity*, January, 1920, p. 16.)

FRENCH (particularly Algerian) HYBRIDS.

Let us now proceed to consideration of forms which have been looked upon as hybrids. The names have been arranged, for convenience, in alphabetical order, and the descriptions and remarks have been translated by me from Dr. L. Trabut's paper "Bulletin de la Station des Récherches Forestières du Nord de l'Afrique (Alger)," tome i, p. 140 (1917), except in the case of *E. jugalis* Naudin.

E. algeriensis Trabut.

E. amplifolia Naudin.

E. antipolitensis Trabut.

E. Bourlieri Trabut.

E. Cordieri Trabut.

E. gomphocornuta Trabut.

E. jugalis Naudin.

E. occidentalis Endl. var. *oranen is.*

E. pseudo-globulus (Hort.) Naudin.

E. Trabuti Vilmorin.

E. Stuartiana x *globulus* Trabut.

DESCRIPTION.

CCXCII. × *E. algeriensis* Trabut.

Reputed parents, *E. rudis* Endl., and *E. rostrata* Schlecht.

Another hybrid form seems to me worthy of attention. It is intermediate between *E. rudis* Endl, and *E. rostrata* Schlecht.

After a certain leaning towards *E. globulus,* one decides to give the preference to the "Red Gum" Eucalypts. Under this name have been propagated *E. rostrata, E. rudis,* and *E. tereticornis.* These three species are found together in the plantations made towards 1880, in which *E. rostrata* is in greatest quantity. These trees have almost the same appearance. *E. rudis* has always a trunk covered with scaly bark, while the two others have a smooth bark, because of the exfoliation of the outer bark, as in the case of the Plane. *E. tereticornis* has an elongated bud, with a long operculum, the filaments of the stamens are not folded back, but straight. *E. rostrata* has a little bud with a hemispherical operculum, surmounted by a long beak; the stamens have the filaments bent back before expansion.

These three species are hybridised so well that in their descent it is difficult enough to make an exact determination. One of these forms, well characterised, is to-day very widely spread, and further, it acclimatises itself, for one finds numerous specimens of it growing spontaneously everywhere on the banks of streams.

In 1904 I described it under the name of *E. algeriensis* in the *Rev. Hort. d'Algérie.*

I well know that it is inconvenient to name as legitimate species forms of hybrid origin, which have been produced under cultivation. But it is also very inconvenient not to clearly and simply indicate plants distinguished by horticulturalists and agriculturalists who propagate them.

It is also a difficult matter for botanists—the presence of a new species of Eucalyptus, foreign to Australia, and reproducing itself like a native plant in North Africa. That is, however, the case of *E. algeriensis*.

E. algeriensis is an example of acclimatisation by means of hybridisation; the hybrid descent offers more facility, by its variations it has a greater facility for adapting itself to a new milieu.

Here is a description of this hybrid :—

E. algeriensis Trabut. *Rev. Hort. Alg.*, 1904. *E. rostrata* x *rudis* Pl. xii.

Lofty tree with a pyramidal shape when young, trunk with smooth bark coming away in pieces; leaves glaucescent, pendent, straight or falciform, lanceolate, oval, large on young specimens; inflorescence in axillary umbels of seven to nine flowers, rarely more; flowers pedicellate, white with an operculum terminated by a short umbo, capsule small, exsert, exceeding the calyx-tube by a little less than half, and opening by erect valves.

E. algeriensis differs from *E. rudis* in its smooth trunk, its smaller flowers, in its hemispherical operculum, not rostrate, or only shortly rostrate; it differs at first sight from *E. rostrata* in its white buds, like those of *E. rudis*. *E. rudis* flowers in winter till December, *E. algeriensis* flowers in the spring, while *E. rostrata* only flowers in July-August, and has a special odour.

The winter flowering of *E. rudis* seems an obstacle to its pollination by *E. rostrata*, which flowers in summer, but it is observed in *E. rostrata*, as in *E. rudis*, that there are several delayed flowers, which are sufficient for a cross-pollination. The number of *E. algeriensis* trees to-day is very considerable. There exists notably a large number at the Forestry Station at Bainen, and the Forestry Service, which has recognised its merit, has propagated it for several years as Red Gum. (This Australian name is in the original.)

In this group of Eucalypts, after the fall of the operculum, the stigma emerges above the stamens when bent back; also at this time cross-fertilisation is very easy.

If one examines the Eucalypts which reproduce themselves spontaneously, especially along the banks of streams, one will recognise that they belong to this species of hybrid origin. It is for this reason that the name *algeriensis* has been chosen. In the near future this tree will take an important place amongst the spontaneous vegetation of Algeria, where it is well acclimatised and naturalised.

The wood of *E. algeriensis* does not differ from the wood of other Red Gums. It is a red or pink timber; it is easier to work than that of *E. globulus*, with straighter fibre, and less subject to split. *E. algeriensis* seems to accommodate itself to all soils, but it prefers those which are somewhat damp. At the Duperre Railway Station can be seen one of the largest of Algerian Eucalypts, which is *E. algeriensis*.

This hybrid must have been produced as the result of the first sowings of Red Gum from seed of Algerian origin, for one finds it in most of the plantings made about 1880. There are some specimens of it with a trunk from 2·50 to 3 metres in circumference.

With reference to Dr. Trabut's remarks *re* species which pass as Red Gum in Algiers, it is not proper to include *E. rudis* in such a list. It is not known as Red Gum in Australia, its timber being rather pale and very inferior. See Part XXXIII, p. 75 of the present work.

CLX. E. amplifolia Naudin.

I have shown, p. 20, Part XXXI, Plate 131, that this species is a valid Australian one. Dr. Trabut is under a misapprehension in looking upon it as a hybrid. I continue the translation.

In the Red Gum plantations one also finds, with an infinite number of forms of *E. rostrata*, some *tereticornis* very polymorphous, and verging towards *E. rostrata*. Amongst this evidently hybrid descent Naudin thought he could distinguish as a species a very fine tree which he has named *E. amplifolia*, and of which the following are the characteristics :—

E. amplifolia Naudin (Pl. xiii).

A strong tree with a smooth trunk; young leaves very large, oval, leaves of the adult tree oblique, lanceolate, pointed or oval; floral umbels with long peduncles, from nine to fifteen flowers borne on pedicels as long as the flowers; calyx-tube short, bearing a white operculum elongated into a long attenuated rostrum, and twice the length of the calyx-tube; the outer stamens straight, the inner ones with flexuose filaments; fruits spherical, capsule small, jutting out above the very thick calyx-tube; opening by three to four straight valves, seeds not very numerous.

E. amplifolia varies greatly in its seeds. One can distinguish it from the *E. tereticornis* type by its umbels with more numerous flowers, by the bud surmounted by a shorter operculum, contracted into a beak.

It is presumed that, by the constant action of hybridisation, it will become more and more difficult to distinguish the primitive species comprised under the general denomination of Red Gum.

E. rudis, rostrata, tereticornis, under the influence of cultivation, have given and will give new forms, which are very interesting on account of their great vigour and perfect adaptation. For the multiplication of these trees it is important to collect seeds from well-grown specimens, which are generally hybrids.

DESCRIPTION.

CCXCIII. × *E. antipolitensis* Trabut.

Reputed parents, *E. globulus* L'Her., and *E. viminalis* Labill.

In *Proc. Roy. Soc., Tas.*, 1918, p. 89, I have stated that I look upon it as conspecific with *E. unialata* Baker and Smith. I am of opinion that they both originally arose from a cross or crosses between *E. globulus* and *E. viminalis*, but whether they are really indentical I prefer to suspend my judgment.

. . . . . .

At the Villa Thuret at Antibes (Southern France), where there is a collection of Eucalypts made by Naudin, I have especially observed a very fine subject, worthy of propagation. Naudin had provisionally labelled it *E. viminalis* var. *longifolia*. The examination of the organs of reproduction as of vegetation leave no doubt as to the parentage of this form with *E. globulus*. I propose to call it the Antibes Eucalyptus.

E. antipolitensis n. sp. (Plate XV bis.).

A tall tree, trunk covered with fissured bark; branches smooth by reason of the falling of the old bark; young leaves sessile, alternate, opposite, often in threes on the same branch, broad and obtuse at the base of the branch, then oval, glaucescent, with the odour of *E. globulus*; adult leaves thick, long-lanceolate, falciform, dark green, dotted with large essential oil dots, umbels axillary, with three flowers on a short peduncle, buds sessile, verrucose, hoary, calyx-tube angular, operculum slightly longer than the calyx-tube, hemispherical, mucronate, fruit from 12 mm. in diameter, with 3–4 valves not erect or very slightly so; fertile seeds black, angular, without appendages. Villa Thuret, Antibes.

This Eucalyptus was sown by Naudin very probably as *E. viminalis*; he called it var. *longifolia*.

At first sight it is distinguished from *E. viminalis* by its habit, its stem, its foliage, reminding one *E. globulus*. The buds and the fruits are much larger than those of *E. viminalis* and strongly resemble those of *E. globulus*; the fruits are much smaller than in this species, always in threes; they are slightly verrucose, and show a slightly different mode of dehiscence. The young leaves resemble those of *E. globulus* and have the same odour, but they are distinguished from it, however, in not being stem-clasping; the branches which bear it are angular, but not nearly so quadrialate as in *E. globulus*.

E. antipolitensis is a very fine tree, which has not yet been propagated; it has numerous capsules in which the number of the fertile seeds is restricted, but quite sufficient to insure propagation.

DESCRIPTION.

CCXCIV. × *E. Bourlieri* Trabut.

Reputed parents, *E. globulus* Labill., and (?).

. . . . . .

E. globulus Labill has given several hybrids easy to recognise by the young leaves, which have preserved more or less the character of *globulus*, and also the content of Encalyptol. One of the most interesting is a fine Eucalypt which appeared in a sowing of *globulus* at my colleague's place (Dr. Bourlier's) at La Reghaia.

E. Bourlieri Trab. *Rev. Hort. Alg.*, 1903, p. 327, Plate XIV.

(Preliminary note *op. cit.* August, 1901, p. 239).

A tree of large stature, biform in the juvenile stage, branches pruinose, leaves opposite, sessile, oval, oblong; stem straight, covered with a network of fine dry bast, which easily comes away; leaves long, lanceolate, pointed straight or curved, pendent, dark green, petiolate, attaining 15–27 cm. long by 22–24 mm. broad; the angle of divergence of the secondary nerves is about 25 degrees; the two faces equally have stomata, 175 to the square mm.; the inflorescence is in an axillary cyme of three flowers borne on a flattened peduncle of 5–6 mm.; the bud is sessile, 15 mm. long with an angular, verrucose, pruinose, whitish, broad, conical operculum, surmounted by a protuberance; fruit generally solitary in the axils of the leaves, hemispherical, barely marked with two angles, pruinose, glandular, punctate, attaining barely 10 mm.; opening by 3–4 slits which let the brown non-appendiculate seeds escape.

This Eucalypt differs greatly from *E. globulus* in the capsule, but the young bud and the young leaves recall this species. It is not possible to ascertain the male parent.

This Eucalypt is not very fertile; the tree has an exuberant foliage and a very fine appearance.

DESCRIPTION.

CCXCV. × *E. Cordieri* Trabut.

Reputed parents, *E. globulus* Labill., and *E. goniocalyx*, F.v.M.

From 1873 M. Cordier observed in the sowings of *E. goniocalyx* F.v.M. specimens having a good deal of resemblance to *E. globulus*, and he made a figure in a fine Atlas which he bequeathed to the Botanical Laboratory of the School of Agriculture, a form that he called a *E. goniocalyx* hybrid of *E. globulus*.

There still exists in the Cordier collection a certain number of these specimens, intermediate between *E. goniocalyx* and *E. globulus*. I propose to call them *E. Cordieri*, in memory of the first botanist who recognised the important role played by hybridisation in the multiplication of forms of Eucalyptus obtained in X cultures.

E. Cordieri Trab. (*E. goniocalyx* x *globulus*) (Cordier, *Atlas Eucalypt*, 1873, pl. 28 (Plate XV)).

A tall tree, with the appearance of *E. globulus*. Young leaves opposite, rounded, cordate, with the same odour as *E. globulus*; adult leaves thick, lanceolate, falciform, very like those of *E. globulus*; umbels axillary, from 3–7 flowers; peduncles compressed, short; flowers sessile, bud pruinose, calyx-tube angular, operculum slightly exceeding the calyx-tube, hemispherical, mucronate; fruit very variable, often with an angle of 8–10 mm. in diameter, with 3–4 triangular valves, which are not erect, sometimes included, most often at the level of the edge of the calyx-tube.

It seems that this form appeared in the sowings of seeds coming from Australia, which leads me to think that Australian botanists did not appear quite certain as to the limits of *E. goniocalyx*, and if a close observation of this species had led them to separate, notably *E. Cambagei* Deane and Maiden (*E. elaeophora* F.v.M.), *E. paludosa* R.T.B., and from another side to separate from *E. globulus* *E. Maideni* F.v.M., they would find themselves confronted with forms arising from hybridisation. It even seems that *E. goniocalyx* is joined to *E. botryoides* by other intermediate forms.

E. elaeophora F.v.M. (*E. Cambagei* Deane and Maiden) is a species quite distinct from *E. goniocalyx*. See p. 275, Part XIX of the present work. *E. paludosa* R.T.B., is a synonym of *E. ovata* Labill. See p. 134, Part XXVII. *E. goniocalyx* and *E. botryoides* are widely different. The former is a Gum with pale-coloured timber; the latter is a rough-barked species with red timber. (This last paragraph by J. H. Maiden.)

DESCRIPTION.

CCXCVI. × *E. gomphocornuta* Trabut.

Reputed parents, *E. gomphocephala* DC., and *E. cornuta* Labill.

Several other hybrid Eucalypts have made their appearance in Algerian cultivations, and are worthy of note.

One of the most interesting is *E. gomphocornuta* Trabut. This Eucalypt has been noticed in a plantation of *E. gomphocephala* D.C., made by Dr. Bourlier at La Reghaia, the seeds coming from the Cordier collection.

Eucalyptus gomphocornuta Trab. *Rev. Hort. Alg.*, 1904. See August, 1901, p. 239, and 1903, p. 326.

A tree of good pyramidal shape, with abundant dark green foliage; trunk with a persistent bark, finely fissured; leaves unequal, oval, pointed, bent, pendent, shining, coriaceous, dark green, with long petioles, attaining to a length of 20 cm. by 22 mm. broad, the angle of divergence of the secondary nerves

varies from 30 degrees in the narrow adult leaves, to 50 degrees in the short large leaves, the two faces with an equal number of stomata, about 288 to the square mm. The inflorescence is in axillary umbels, borne on a peduncle of 3 cm. long, flattened the whole length. The flowers, to the number of 3–7, are borne on a thick short pedicel; the bud, which before expansion is 25 mm. broad, is covered by an operculum which is at first cylindro-conic, and then swelling at the base so as to project over the calyx-tube; fruit campanulate, elongated, from 15 mm. long to 10 mm. broad, opening by four pointed fragile valves; the seeds without appendages are of the colour of dark mahogany; the cotyledons are deeply bifid.

E. gomphocornuta, which has a general appearance of *E. gomphocephala* DC., is distinguished very easily by its very short buds, and surmounted by a long conical operculum not hemispherical, projecting like the cap of a mushroom, and by its campanulate capsule bearing pointed valves which recall its relation to *E. cornuta* Labill (Fig. 3).

In the plantation of Reghaia the *gomphocornutas* are distinguished by a greater height and a thicker trunk.

I have already (1904) recorded the fact that it was contemplation of specimens of *E. gomphocornuta*, which so obviously partook of the well-marked characters of the reputed parents, that removed the last haze of doubt from my mind as to hybridisation in the genus.

DESCRIPTION.

CCXCVII. × *E. jugalis* Naudin.

In "Description et Emploi des Eucalyptus introduits en Europe principalement en France et en Algérie" (Second Mémoire par Charles Naudin, Antibes, 1891, p. 37).

Reputed parents, *E. melanophloia* F.v.M. and (?).

Following is the original description :—

Petit arbre de 5 à 6 mètres, à en juger par les exemplaires qui me sont connus, biforme, tout entier d'un gris blanchâtre pruineux. A l'état juvénile, les feuilles sont opposées, sessiles, ovales ou même largement ovales, aiguës ou obtuses, cordiformes à la base, longues de 4 à 5 centimètres, larges de 3 à 4. A l'état adulte, elles sont alternés, pétiolées, ovales-oblongues et même lancéolées, et dans ce cas elles peuvent avoir 10 à 12 centimètres de longueur, sur 1 à 2 de largeur. Les fleurs sont en cymes axillaires, le plus souvent triflores, mais qui portent quelquefois 5 ou 7 fleurs courtement pédicelées, de forme ovoïde avant leur épanouissement, très pruineuses, et dont l'opercule arrondi, terminé par un court mamelon, se distingue à peine du tube du calyce avant sa chute. Le fruit, à peu près hémisphérique, largement ouvert, de la grosseur d'un pois, contient une capsule à 5 ou 6 loges, aplatie à son sommet et dont les valves, à sa maturité, arrivent à peine au niveau du bord du tube calycinal.

Cette espèce, qui me paraît jusqu'ici bien caractérisée, existe dans divers jardins de la Provence, ainsi que dans les plantations de l'administration forestière de Roquebrune, près de Fréjus. Nous en avons plusieurs exemplaires adultes à la villa Thuret, très semblables les uns aux autres. Malgré toutes mes recherches, je ne l'ai trouvé décrit nulle part. Quelques horticulteurs lui donnent le nom de *fissilis*, qui n'est cité dans aucune Mémoire d'eucalyptographie. Pour ne rien préjuger, je l'ai nommé *jugalis*, qui rappelle la disposition par paires des feuilles du premier âge.

At p. 16 Naudin puts it in the group "Espèces biformes dont les ombelles axillaires contiennent plus de trois fleurs, sauf les cas d'avortement ou de chûte prématurée (ils sont frequents dans l'*E. jugalis*) :—

E. coccifera, goniocalyx, myrtiformis, Huberiana, Mazeliana, jugalis, gracilipes Risdoni."

DESCRIPTION.

Eucalyptus occidentalis Endl., var. *oranensis* Trabut.

E. occidentalis Endl. var. nov. *oranensis*. The typical form is a medium-sized and irregular tree. In the Department of Oran there is a race very different and worthy of a name. The flowers and the capsules are borne on long and slender peduncles and pedicels. The tree is of fine appearance as one can see in the Domain of L'Habra. This form, or one very closely related to it, has been distinguished in America under the name of *E. californica* Hort.

DESCRIPTION.

CCXCVIII. × *E. pseudo-globulus* (Hort.) Naudin.

Reputed parents, *E. globulus* Labill, and (?).

E. pseudo-globulus Hort. In the sowings of M. Trottier one may observe a *globulus* with very long leaves, with flowers in threes on a rather long compressed peduncle, with fruit half as small as in *globulus*. This Eucalypt comes true by seed.

It is very difficult to affirm that this deviation from type is of hybrid origin, but it is well characterised, and remains constant.

This form is referred to by Naudin in the following words:—"Nous ne lui connaissons jusqu'ici qu'une seule variété, celle qui a reçu le nom de *pseudo-globulus*, qui ne se distingue du globulus ordinaire que par le volume de ses fruits, de trois ou quatre fois plus petits que ceux du type commun. Il y a d'ailleurs tous les passages entre les extrêmes de volume."

I have received specimens from Dr. Trabut. I have notes on it in *Proc. Linn. Soc., N.S.W.*, xxviii, p. 899 (1903) and xxx, p. 499 (1905). In the latter reference I was not satisfied of its hybrid nature, but I am now.

DESCRIPTION.

CCXCIX. × *E. Trabuti* Vilmorin.

Reputed parents, *E. rostrata* Schlecht., and *E. botryoides* Sm.

Synonym.—*E. Rameliana* Trabut non F.v.M., in *Revue Horticole de l'Algerie*, No. 8, p. 237 (August, 1901); *Bulletin Agricole de l'Algerie et de la Tunisie*, p. 326 (15th July, 1901); Maiden in *Proc. Linn. Soc. N.S.W.*, xxviii, p. 903 (1903).

During my stay at the Nuestapha Hospital, I have, since 1874, sown there several Eucalypts obtained from the Trottier collections. Two species were planted together in the garden, *E. rostrata* and *E. botryoides*.

In 1886 an *E. botryoides* of this sowing seemed to me worth reproducing, and I had some seeds collected, as also in 1887, 1888, 1889. Of plants obtained from these seeds, a small number were *E. botryoides*, the others were very different, and I was unable to attribute them to a species already introduced.

In 1891, after careful study, I was convinced that these Eucalypts, from a sowing of *E. botryoides*, were hybrids, *botryoides* x *rostrata*, and I gave a description of them at the Marseilles meeting of the French Association for the Advancement of Science. The new Eucalypt was dedicated to Ramel, and described under the name of *E. Rameliana*, hybrid *botryoides* x *rostrata*.

This name, which had for its object the honouring of the apostle of Eucalyptus in Algiers, could not be maintained; von Mueller had already given Ramel's name to a form of *E. pyriformis* Turcz. H. de Vilmorin called my hybrid *E. Trabuti*, and it is under this name that it figures in his catalogue of seeds of trees. Here is the description :—

E. Trabuti H. de Vilmorin in Cat. *E. Rameliana* Trab. (non Mueller) *Ass. Franc. Adv. Science*, 1891. *E. botryoides* x *rostrata*.

A tree of rapid growth, branching very early, and of a regular pyramidal shape; the trunk often with a cracked bark; foliage dense, dull green; leaves coriaceous, oval, lanceolate, slightly falcate, very pointed, finely nerved, the two pages distinct, the upper more shiny and with about 70 stomata to the square mm., the lower paler and 150 stomata to the square mm. (in *E. botryoides* the leaves have only stomata on the lower surface, 200 to the square mm.; in *E. rostrata* these openings are equally spread on the two pages). These leaves are from 15 to 22 cm. long, and 30–45 mm. broad; the angle of divergence of the secondary veins is 55 degrees to 60 degrees. It is a mean between the angle of divergence of *E. botryoides*, from 65 degrees to 70 degrees, and that of *E. rostrata*, which is from 45 degrees to 50 degrees. The inflorescence is in axillary umbels, borne on a slightly flattened peduncle under the flowers, which have short pedicels equal to the calyx-tube; their number varies from seven to twelve. The bud has a conical operculum, generally rostrate. The fruit is of about the size of a pea, and is semi-oval, the calyx-tube sometimes extending beyond the capsule, which opens when mature by means of valves whose extremities are sphacelate and deciduous.

Because of its vigour, the regularity of its shape, and the density of its foliage, this Eucalypt merits attention. The wood of *E. Trabuti* is red; I have had furniture made of it which had all the appearance of mahogany.

In order to verify the rapidity of growth of this hybrid, I have had a row of *E. rostrata* and *E. botryoides* planted, alternating with *E. Trabuti*. After ten years all the hybrids had largely dominated the parents, which were often atrophied between two hybrid trees.

The facts on which I base my opinion that *E. rostrata* is the male in this hybrid are the following :—

The seed-bearing *E. botryoides* was surrounded by *E. rostrata*; on the outside there was only *E. globulus*. The botanical characters are exactly intermediate between the two parents. The mixed character of the leaves is evident. As to the capsule, it could not have a more intermediate character; in *E. botryoides* the valves of the capsule dry up and fall in order to set free the seeds; in *E. rostrata* the valves stand erect and the upper half dries up and falls.

E. Trabuti greatly resembles *E. resinifera* Sm., and if I had not many times seen this hybrid formed from a seed gathered from *E. botryoides* I should not have distinguished it. *E. resinifera* differs in the venation of the leaves, with hypogenous stomata, and by the valves of the capsules, which are entirely persistent and erect.

E. punctata DC. also greatly resembles *E. Trabuti*; it differs in the absence of stomata on the upper surface of the leaves.

In collections there has been named *E. resinifera* from varying forms, and I think that a certain number are *botryoides* x *rostrata*; one recognises them by the very peculiar character of the valves, partly deciduous at the moment of dehiscence of the capsule, a character inherited from *E. botryoides*.

The descendants of this hybrid form, that I have been able to observe, are constant in their characters, always in certain specimens. One can notice a certain tendency towards *E. rostrata* rather than to *E. botryoides*, which in practice will lead to joining *E. Trabuti* to the group of the " Red Gums."

In the plantations of the Forestry Station of Bainen I have seen in an area planted with *E. rostrata* a large number of *E. Trabuti*, with a slightly exsert capsule; it is possible that these specimens come from a *rostrata* hybridised by a *botryoides*. These trees are distinguished by their great vigour.

For what is meant in Algiers by " Red Gum," see under *E. algeriensis*, p. 72.

Professor Trabut has sent me a number of specimens that he states are hybrids between *E. botryoides* and *E. rostrata*. Some of them depart from the type of *E. Trabuti*, and approach the assumed parents more or less closely.

Eucalyptus Stuartiana × *globulus* Trabut.

At the Forestry Station of Bainen, in a plantation of *E. Stuartiana* F.v.M., there is a fairly large number of specimens easy to distinguish from the type by larger fruits and sculpture, or young leaves recalling absolutely those of *E. globulus* by the shape and by the peculiar odour. This hybrid will be described later on.

I have not seen a description, figure, nor specimens of this reputed hybrid.

Following are some notes by Dr. Trabut on experiences with certain Australian species in Algiers :—

E. botryoides Sm.

Although little distributed, this species presents numerous very different forms in collections, and certainly of hybrid origin; it tends to *E. goniocalyx*.

These hybrids of *botryoides* are generally very fine trees, worthy of the attention of cultivators.

The *botryoides* type shows on the contrary a tree of rather slow growth and medium dimensions.

E. goniocalyx and *E. botryoides* are species not very closely related. (J.H.M.)

E. polyanthemos Hort.

This species has given me a very ornamental hybrid with its fine foliage and its abundant inflorescence; but no capsule has developed; it remains sterile. There is a fine specimen in the gardens of the hospital.

The study of the pollen of these hybrids of Eucalyptus may sometimes permit us to establish the hybrid nature of a form observed, but the sterility in this case appears to be exceptional.

E. punctata DC.

To the group of the Red Gums one may attach also *E. punctata* DC., a very fine tree, which recalls *E. Trabuti*. I only know one group of it, which is not absolutely typical, at M. Bertrand's at Sidi-Alé. The seeds were received under the name of *E. resinifera*.

E. resinifera Sm.

E. resinifera Sm. is very rare; it is found in the Cordier collection, but it does not propagate itself.

E. robusta Sm.

In the sowings of *E. robusta* of seeds coming from the Cordier collection I have been able to observe some very interesting hybrid forms. In the plantings of Dr. Bourlier at La Reghaia, one of these forms turned out to be *E. Kirtoniana* F.v.M., which is very probably a hybrid between *E. robusta* and *E. rostrata*, according to Maiden, the Australian Eucalyptologist. *E. Kirtoniana* has not been sown by Cordier, but it is shown in the sowings of *E. robusta*, which tends to show that in Australia there are species of Eucalyptus of hybrid origin.

E. Kirtoniana F.v.M. is doubtless a good species. See p. 200, Part XXIX of the present work.

A SOUTH AFRICAN HYBRID.

We now proceed to South Africa, and I offer a very interesting hybrid from thence, whose abnormality was discovered by the local Forest Officers :—

DESCRIPTION.

CCC. × *E. Insizwaensis* Maiden n.sp.

Reputed parents, *E. robusta* Sm., and (?).

A tree of medium size, with a smooth bark " somewhat resembling that of *E. globulus* at the same stage."

Juvenile leaves broadly lanceolate to almost ovoid (say about 13 cm. long to 6·5 cm. broad), the base slightly lobed and the leaf on a short petiole. The under side dull, the upper side shiny, the rachis glaucous, and perhaps the whole of the foliage glaucous in a young state.

Mature leaves pale green, the upper surface shiny, not coriaceous, lanceolate, with a long tapering apex, the base tapering into a moderately long, flattened, and somewhat twisted petiole, venation distinct, but not very prominent, moderately spreading, the secondary veins making an angle of 30 or 40 degrees with the midrib, the intramarginal vein not far from the margin.

Flowers axillary and in threes, sessile on broad peduncles of about 1 cm. long, the buds glaucous, the calyx-tube tapering, ribbed with two opposite ribs so prominent as to be almost winged, the operculum conical or umbonate, when dry slightly exceeding the calyx-tube in diameter at the commissure, surface glandular, about half the length of the calyx-tube.

Fruits campanulate, ribbed, with two opposite prominent ribs, rather large, exceeding 1·5 cm. in length and less in width, with a sharply sculptured, rather narrow rim, the capsule well sunk, so that the tips of its four valves barely reach the orifice.

RANGE.

This comes from South Africa, being collected at Insizwa Plantation, Mount Ayliff district, Cape Province. It was received from the Chief Conservator of Forests at Pretoria, who states that the District Forest Officer, Kokstad, collected it.

AFFINITIES.

The history of the specimens is as follows :—

" The trees from which herbarium specimens Nos. 2,735 and 2,736 were taken were raised with plants of *Eucalyptus saligna* ([?] *E. grandis* (Hill) Maiden, " 'Flooded Gum,' J.H.M.) from seeds collected from trees of this species growing in a shelter belt, together with *E. globulus*, at the Kokstad Plantation (Transkei). It has not, however, been possible to trace the origin of the shelter belt of trees." (J. J. Kotze.) Also " Insizwa Plantation, Mount Ayliff district, Cape Province."

1. With *E. robusta* Sm.

It seems to me that its closest affinity is with this species. Compare Part XXIII, Plates 97 and 98. *E. robusta* is, however, only occasionally three-flowered; the juvenile foliage does not closely resemble that of the hybrid, while the mature leaves have a greater resemblance. There is a resemblance, though not a close one, in the buds, but it is in the size and shape of the fruits that the resemblance is closest, but those of *E. robusta* are not ribbed. The smoothness of the bark of the hybrid removes it from *E. robusta*.

2. With *E. longifolia* Link and Otto.

Some of the remarks under *E. robusta* would apply to the present species. *E. longifolia* has flowers in threes, and sometimes there is a tendency to ribbing of the calyx-tube.

3. With *E. grandis* (Hill) Maiden.

In its general glaucousness and smoothness of its bark, the hybrid shows some affinity to the above species. Compare Part XXIII, Plate 100.

4. With *E. globulus* Labill.

E. globulus has been mentioned; it is growing near an *E. globulus* plantation, and in its glaucousness and pale timber, and in the general appearance of its buds and fruits, it presents a distant similarity to that species.

THE BARK.

(Continued from Part LI, p. 59.)

3. CLASSIFICATION OF TREES IN GENERAL BY MEANS OF THEIR BARKS.

It would appear that there are few classifications in other parts of the world, which are based on the bark. That of Kerner and Oliver, which I proceed to quote, is one of them.

1. First, the *scale* bark, which is detached annually in the form of shields and plates, to be seen especially well in the stems of planes, almond willows, and many species of Australian Eucalyptus.

2. Second, the *membraneous* bark, which separates as dry films and ribbons; this form of bark is shown in the common Birch (*Betula alba*).

3. Third, the *ringed* bark, which is detached from the stem in the form of thin, irregularly fissured tubes, and is especially developed in the Mock Orange (*Philadelphus*).

4. Fourth, of which the Vine (*Vitis vinifera*) may serve as an example, is the fibrous bark, which is detached as numerous stiff threads.

5. Fifth, there is the fissured bark, which is produced on the stems of the oak, lime, ash, and numerous other leafy trees. In this form the bark is not detached in large pieces, but is ruptured by the increasing thickness of the stem, causing longitudinal fissures with a sinuous or zig-zag course, by which, in one case only, narrow ridges and grooves, and in other cases, broad angular patches, are outlined. (Kerner and Oliver, i, 719–20.)

Endeavouring to apply the above to Eucalyptus, under No. 1 would be the Bloodwoods (Lepidophloiæ), while No. 2 would come nearest to the most lamellar or extreme forms of the Lepidophloiæ, such as *E. miniata* and *E. phoenicea.*

I know no representative of No. 3, but in No. 4 we could have Peppermints and Stringybarks, according to the thickness of the fibrous covering, while of No. 5, the Ironbarks would be an extreme case, and certain Gums, *e.g.*, *E. viminalis*, *stellulata*, which have more or less rough bark on the butts.

Kerner and Oliver (p. 720) go on to say:—

The form of the bark is so characteristic that by it alone the species of the tree can be recognised; it therefore constitutes an important feature in the picture of a tree, nor can it be altered according to fancy. It is inadmissible that artists should combine the studies they have made of various trees as they please, perhaps putting the crown of an oak on the trunk of a plane.

The above remarks are written with European trees in view, but in Australia the barks of trees have not been even so carefully studied. It is painful sometimes to be asked to admire a painting which may possess many merits, but in which the

barks of the trees are impossible. The time will come when photographs and other true illustrations of types of barks of Australian trees will find their way into the schools, and lessons on the barks of Australian trees and the shapes of trees, and notes on the situations in which trees with special barks are found, will be available to students. As a rule, I am afraid that some artists, sensitive of their weak spots in Australian tree-drawing, give us vague drawings that are indeterminable. At all events, I have often failed to comprehend the tree which has been in an artist's mind, simply because I could not determine the bark. I am, of course, referring to drawings with some detail, and not to impressionist sketches.

I have often, on a railway or coach journey, heard people deplore the monotony of the Australian forest. There is no necessity to make comparisons of the forests of one country with another, but I say without hesitation that, to me, the Australian Eucalyptus forest is one of the most varied and charming of any country I know. Leaving aside the habit of the tree, its size, canopy, colour of foliage, the study of the barks may become of never-ending interest. I have often been thanked by fellow-travellers, who have said that I had given new interest to a journey by pointing out the marvellous variation in barks alone. Where curiosity is excited, there may be a stimulus to further knowledge, and instead of the parrot cry of the monotony of the bush we shall have the feeling statement that our trees increase in charm as we know more about them. This depreciation of the Australian bush is observed in regard to other phases of it. As a very general rule it is not spiteful, but rather jocular, and springs from ignorance. As knowledge progresses, it will tend to disappear.

In "A Text-book of Botany," Coulter, Barnes, and Cowles (vol. ii, Ecology) these distinguished authors discuss barks more from the physiological aspect, and the (chiefly) American barks they cite by way of illustration have, to some extent, their analogies in Eucalyptus. Following are some extracts, with my brief comments in square brackets :—

1. *Smoothness and roughness—Exfoliation.*—When the epidermis persists, young stems are smooth, except in the neighbourhood of lenticels and leaf-scars.

For a few years most stems remain smooth or smoothish, owing to the development of bark tissues as the stem increases in diameter. In some trees (as in the Beech, *Fagus*) continued lateral growth causes the bark to remain thin and smooth throughout life; the tropical rain-forest in particular is rich in smooth-barked trees. . . . (p. 708). [These remarks also apply to Eucalyptus, many of which, tropical or sub-tropical rain-forest, *e.g.*, *E. saligna*, *E. Torelliana*, are Gums or Smooth-barks.]

2. In most trees, new phellogen areas develop at deeper levels or lateral growth fails to keep pace with diametric increases, so that the bark splits and becomes variously roughened. Some trees, as Burr Oak (*Quercus macrocarpa*), become furrowed very early, while others, as Bass Wood (*Tilia americana*) presumably remain smooth-barked for a very long time, but ultimately become furrowed. [Such trees as these have much in common with some of our Ironbarks, even if the Oak, &c., barks be not so rough and hard.]

3. *Tesserae.*—"Alligator Bark" is caused by the division of the bark into blocks by somewhat equidistant transverse and longitudinal furrows (as in *Nyssa*) (p. 708). [Amongst the Eucalypts *E. tessellaris*, the Moreton Bay Ash, is an excellent example of this.]

4. In a number of trees, the bark exfoliates in definite layers (Fig. 1034), the separation being in the zone of weakness, known as the *separation layer*, which is composed of loose and weak cells that alternate with the denser and stronger cork layers (p. 709). [The figure above quoted is that of a Ribbony bark, analogous to, *e.g.*, *E. viminalis*, on a very reduced scale.]

5. In trees with scaly bark, the cork layers separate into patches or arcs, as in the Sycamore (*Acer pseudo-platanus*), Cherry (*Prunus Cerasus*), and Pine (*Pinus*). [The bark of some Pines has a close superficial resemblance to that of some of the Bloodwoods, *e.g.*, *E. corymbosa*.]

6. While in plants with ringed bark, the cork layers form concentric cylinders, and the bare shreds or slivers off (as in the Grape, *Vitis*, and Arbor-vitae, *Thuja*). [I can find no useful Eucalyptus analogy here.]

7. In trees with shaggy bark the exfoliating masses are elongated, and in the birches the bark exfoliates in thin papery layers (p. 709). [The Eucalyptus barks which approach nearest to those of the Birches are those of some of the extreme members of the Lepidophloiæ, such as *E. miniata* and *E. phoenicea*, but the resemblance is not close.]

4. VARIATION IN BARKS OF THE SAME SPECIES.

This has been referred to by only a few authors. Following is an illustrative reference :—

> There are exceptions (to Mueller's cortical system), for instance to the Leiophloiæ ; for *E. haemastoma*, *E. saligna*, *E. viminalis*, *E. stellulata*, and *E. punctata* are somewhat half-barked, while instances occur in which *E. tereticornis* has fibrous bark. The different kinds of Box are not always half-barked, and so some of the Hemiphloiæ incline to the Leiophloiæ in extreme age. I have noticed this peculiarity in *E. largiflorens* (*bicolor*) (he probably means the species afterwards known as *E. Bosistoana* F.v.M., J.H.M.), and in some of the Blackbutts (*E. pilularis*) . . . in the Woollybutt (*E. longifolia*), of which the Baron (von Mueller) regards the bark as wrinkled, somewhat fibrous and persistent, I have seen old trees which might have been mistaken for *E. tereticornis*, their trunks having completely shed their bark, and become similar to Gum trees. . . . (Rev. Dr. Woolls in *Proc. Linn. Soc. N.S.W.*, xvi, 60, 1891.)

While there is undoubted variation of bark in the same species, it is proper to point out that it is also a fact that, some of the instances quoted by the older writers are not to the point, because they were unconsciously including two or more species under one name. I have in my mind's eye such cases as *E. paniculata* and *E. fasciculosa* on the one hand, and *E. sideroxylon* and *E. leucoxylon* on the other. The first member of each pair is an Ironbark, and the other a Gum, but, because of the similarities of herbarium material, each pair was looked upon as identical, until realisation of the fact that their barks are totally distinct led to their final recognition as separate species. Dr. Woolls'. reference to *E. tereticornis* occasionally having " fibrous bark " probably refers to *E. exserta*, and so on.

The amount of rough bark at the base of a Gum is well shown in a photograph of *E. Benthami*, to be reproduced later, where it will be seen that a certain specimen could readily be grouped as a half-barked tree. The cause of the unusual amount of rough bark is ringbarking. Such a condition is stimulated by violence in various forms, *e.g.*, cincturing, wounds, insect-action, and also by absence of shelter. Indeed the description of a bark should only be made from a normal healthy tree.

Furthermore, it is a matter of importance to note the size or age of a tree in considering its bark. For example, an Ironbark which may have rough branches may, in the young state, have the upper part of the trunk and the branches smooth. This brings us naturally to consideration of—

Deciduousness of Bark.—Mr. Hill assured me that some of the Gum trees, and perhaps all of them, shed their bark twice in the year. The Stringybark (*E. obliqua*) is one of the most striking instances of this. (Tenison-Woods, speaking of southern Tasmania, in *Journ. Roy. Soc. N.S.W.*, xii, 21.)

The above note on a Stringybark may be supplemented by the case of two Ironbarks, viz., *E. decorticans* in particular, see Part XLVIII, p. 231, and F. M. Bailey (*Queensland Agric. Journ.*, March, 1911, p. 127) quotes Mueller in regard to deciduousness of the bark in two cases of *E. crebra*. (Perhaps, however, *E. decorticans* is really meant.) Of course, the deciduousness of the outer bark of the Gums, of which the Ribbony Gums are extreme cases, is well known.

Here follow a few notes, arranged in alphabetical order of species names, referring to bark-variation. Care should be taken, in reporting anomalous barks, to note if there is any predisposing cause of rough bark, as already briefly referred to :—

E. haemastoma Sm.—Mr. C. T. White, in *Queensland Agric. Journ.*, August, 1920, at p. 70, has a "Note on variation in the bark of two common Eucalypts," and the paper is illustrated by photographs. He shows the ordinary *E. haemastoma* var. *micrantha*, the "White or Scribbly Gum," alongside a "Gum-topped Stringbark," which he calls *E. haemastoma* var. *inophloia*, new variety. (Now see *E. Seeana*.)

E. hemiphloia F.v.M.—This cortical system has its utility; but there are several species which exhibit inconstant characters, as, for example, *E. hemiphloia* in its ordinary state is typical of section 2, but in the high uplands of the Mount Torrens district of South Australia it assumes the characteristics of section 4, and is locally known as "Bastard Stringy-bark." (Professor Ralph Tate.)

E. maculosa R. T. Baker.—A remarkable case is that of a tree of this species in the Federal Territory, on the Yass-Queanbeyan road, in the vicinity of Gungahleen. Normally this is a smooth-bark, with lenticular blotches, but the specimen in question has a bark not only rough all over the trunk, but also crinkled, probably corresponding to a very interlocked timber. A photograph of this tree by Mr. C. J. Weston, Afforestation Officer of the Territory, will be given in due course.

E. microtheca F.v.M.—I have invited attention to the remarkable variation of the bark in *E. microtheca* in my "Forest Flora of New South Wales," vol. vi, p. 20, and also in Part XI, p. 51, of the present work.

E. Seeana Maiden.—After *E. haemastoma*, Mr. C. T. White also shows *E. Seeana* "Narrow-leaved Blue Gum" in its normal, almost smooth-barked form, and a form of the same species with the note : "This tree carried its flaky bark almost to the topmost branches, and is a remarkable variant from the type." Truly the forms, to which Mr. White has drawn attention, are so aberrant, that they should be further investigated. Without doubting the correctness of Mr. White's determinations for a moment, both rough-barked forms appear to be suffering from pathological conditions, which may account, in part, for the extraordinary roughness of the bark.

E. stellulata Sieb.—"I have seen bark of *E. stellulata* (which Mueller includes in section 5), which cannot be distinguished from what are known as Ironbarks." (Maiden in *Proc. Linn. Soc., N.S.W.*, 1278, 1890, and Part V, p. 129, of the present work.) It really belongs to the smooth-barks or Gums, and this Ironbark character is not strictly typical.

E. viminalis Labill.—Luehmann (*Proc. A.A.A.S.*, vii, 524) quotes the remarkable variation in the bark of *E. viminalis* in Victoria. He says :—

> This tree, which grows around the Melbourne herbarium building, shows here, in its sapling state, a smooth, whitish bark, until it attains a diameter of from 4 to 6 inches, then gradually the outer layers remain attached, at first near the base only, becoming rough and brown; as the plant gets older, these layers creep higher and higher up the stem, until, in aged trees, the whole of the trunk and also the larger branches are covered with a thick, rugged, dark brown bark. Within 10 miles inland from Melbourne, already the tree changes its character in this respect, inasmuch as only the lower part of the stem is covered with this rugged bark, while another 10 miles further towards the ranges this species presents a smooth white trunk, except, perhaps, just near the ground. Although the floral characters remain the same, yet anyone seeing only the two extreme forms would certainly consider them two distinct species."

Mr. R. H. Cambage has taken a photograph to illustrate this. The bark of this particular tree is the reverse of the normal White or Ribbony Gum, and it will be found illustrated in due course. So, also, will an excellent photograph of a rough-barked *viminalis* in Studley Park, Melbourne (Hardy).

It has been found, in a number of cases, that trees with barks approximately smooth, in low-lying situations, may become increasingly rougher or more fibrous-barked in more elevated, better drained situations, such as hill-sides or tops of hills. Examples are :—*E. regnans* (the rough-barked variety has been described as *E. fastigata*), *E. saligna* and *E. viminalis*.

5. BARK IN RELATION TO HEAT AND COLD.

In connection with Mr. Cambage's observations, recorded at pp. 318-9, Part L, to show how careful one has to be in interpreting the relation of the bark to resistance to heat and cold, we find that those species which are exposed to the greatest extremes in these directions are the smooth-barked (Leiophloiæ), those which have a naked look. *A priori*, one would expect the Stringybarks, with their blankety covering, to be most cold or heat-resistant, just as we pack a tree with a coat of straw or other non-conducting material to pass it through an inclement winter. We adopt no corresponding method in dealing with trees in relation to hot winds and high temperatures generally, simply because it is not convenient to do so.

Nature's method, as regards Eucalyptus in these situations, is not to employ dead tissue for non-conducting purposes, but smooth, thick, parenchymatous tissue full of water-containing cells, which offer considerable resistance to extremes and changes in temperature.

> The thickness of bark varies considerably with the habitat, being greatest in deserts and other dry situations and in alpine regions, and least in the tropical rain forest. Individuals of a species common to two situations have the thicker bark in the more xerophytic habitat; alpine and light cultures show more bark than lowland and shade cultures. Probably in most cases thick bark is associated with high transpiration, and thin bark with low transpiration. (Coulter, Barkes and Cowles, *op. cit.*, ii, 707.)

6. ADVENTITIOUS SHOOTS.

Let us now give consideration to two intensely practical Australian questions, more or less intertwined :—

1. Ringbarking.
2. Control of Coppice or second-growth.

Under certain circumstances we wish to destroy trees, large or small, and the methods (other than those of the forester) are ringbarking for trees of large, medium, or even small size, and the use of the axe or tomahawk and the mattock for saplings. As the work is usually done, there is always more or less risk of suckers, resulting through imperfect ringbarking, or because of imperfect grubbing.

I preface notes on ringbarking and coppicing by offering translations of two interesting articles, by Planchon and Casimir de Candolle, written many years ago. The physiology of Eucalyptus trees, then recently introduced into Europe, presented very great scientific interest to these eminent botanists. The latter quotes earlier papers bearing on the same subject, and these references are important.

Planchon, 1875.—The *Eucalyptus globulus* presents itself under two very striking aspects: the infantile form, in which the leaves are opposed and sessile; that is, a sort of *larval* state, during which the plant is not apt to flower; and the adult state, in which the leaves are alternate and petiolate, and which is the perfect state, characterised by the presence of fruit and flowers.

It is not necessary to resort to analogies, and to compare this dimorphism of the *Eucalyptus* to those metamorphoses that insects undergo; such, for example, as the changes of the same insect through the forms of caterpillar, chrysalis, and butterfly. In the latter case, it is the individual itself that throws off its successive envelopes, and appears with new forms, resulting from internal effort and changes of the same organs. In the case of the *Eucalyptus*, it undergoes no metamorphosis, but only appears with new organs superadded to the old ones; or, more properly speaking, the tree represents, not an individual, but a foliate collection (the phytons of Gaudichaud), each successive element having its own form independent of the form of the elements which precede and follow it. The resemblances or the differences of these elements do not alter its own individuality. In short, it is a successive *polymorphism*, and not a metamorphosis in the primitive sense of the word.

This *polymorphism* is not, however, a general character of the *Eucalyptus*. It is in a certain measure wanting in the species *Eucalyptus cordata*, which flowers upon branches with opposed leaves. (An isoblastic species, J.H.M.) Here the adult and infantile states are confounded; and without attempting to establish a too narrow assimilation between animals with centralised functions and plants with multiplied elements, it is, perhaps, allowable to compare the infantile and adult forms of the dimorphous *Eucalyptus* to the two states of tadpole and adult of common batrachians (toads, salamanders); whilst the *Eucalyptus* fructifies upon its branches an infantile type which may be analogus to batrachians called *Perennibranches*, which reproduce themselves while preserving the character of larvae to the branchial respiration. Whatever may be the character of this general assimilation, the prominent fact is the existence of two states of foliation among certain of the *Eucalypti*, and only one state among (most, J.H.M.) others. Now, from causes the action of which cannot be foreseen, a *Eucalyptus* of this first group fructifies upon its young branches, and the seeds of the fruits may not, in germinating, reproduce the characters of the branches from which they are derived; will not nature have thus formed by a simple variation of fixed foliage nearly the equivalent of that which is always described as the species? In other words, if we find the habitually sterile branches of a *Eucalyptus globulus* normally fructifying, have we not before us a new form of the type, which, encountered by itself and disconnected with its point of departure, would naturally be described as the veritable species? And what assurance have

we that the accepted good species are not thus derived from actually living or from anterior types? This is only an hypothesis; but the natural polymorphism that we observe in the similar elements of the same plant may well represent, when fixed upon that plant, the variations which, in other circumstances, would become detached and isolated, and live separately, protected by the generation of a certain fixity.

We do not pretend to resolve this complex problem of the species in this manner; but we find here an argument in favour of the general theory of derivation, opposed to the theory of the absolute fixity of the types of successive creations by a sort of repeated miracle. (These were looked upon as advanced opinions half a century ago, J.H.M.) Let us, however, leave these nebulous regions of philosophic speculation and descend to the facts concerning the *Eucalyptus globulus*. . . . (J. E. Planchon's article on *E. globulus* in "Revue de Deux Mondes," 1875, translation by United States Department of Agriculture, pp. 8, 9.)

Casimir de Candolle, 1903.—*Adventitious buds* are those which arise accidentally in indeterminate points of the body of the plant, or on parts of it which do not normally produce them. Their disposition is therefore irregular; that is to say, without relation to that of the leaves and of the ordinary branches. They must not be confused with certain *axillary buds* whose retarded evolution only takes place a long time after the falling of the leaves in the axil of which they have taken birth, and which are called, for that reason, *dormant buds*.

Adventitious buds are met with very often on the trunks or on the branches of trees, and more rarely on herbaceous stems. Many plants produce them also on their roots or their leaves. They are even formed sometimes in the interior of seeds, where they constitute adventitious embroyos.

I am only here concerned with those which are produced on the trunk and on the branches of trees and shrubs. They are always[1] of endogenous origin, arising in the tissue around the cambium. The cellular layer in which the formation of these buds begins has only yet been determined absolutely in a small number of dicotyledons,[2] in which it is found to be the pericycle, and everything leads to the belief that it is the same with other plants of this class.

The shoots issuing from the adventitious buds always exhibit, at the beginning, vegetative characteristics of the young plant of the same species. Also they are never entirely similar to those of the axillary buds of the adult tree. In certain cases they differ from them even in a striking manner. This pecularity of the adventitious shoots deserves to be closely examined, and it is this that I propose to do in the following pages.

I shall commence by recalling that every plant begins, in its development, by the production of phyllomes belonging to the simplest types, such as the cotyledons and the basilar scales which succeed them on the primary stem of many of the species. Then come the true leaves, of which the dimensions and also the degree of complication increase from one to the other, more or less rapidly, until there is attained the type of the definite leaves characterising the species to which they belong. One may then say that every plant presents, in the course of its individual evolution, a more or less varied heterophylly. There are produced sometimes, at the same time, changes in the form and the structure of the successive axes. Finally, the phyllotaxy even of the leaves may also change, and it is then the lower leaves which present arrangements the most condensed in character.

The different phases of individual evolution succeed each other generally quick enough, because many plants have acquired already on their primary stem their adult leaves. In this case the latter differ from those which come later on the adult plant. They are distinguished, however, almost always by a certain juvenile appearance belonging to characters it is difficult to define, such as the slight differences of form, of consistence, or of colouring. This same juvenile appearance is always found in the adventitious shoots of the adult plant. There are also species in which the young plant has very similar leaves, as to form and dimensions, to those of the adult plant, but having a simpler internal structure. The first leaves of the adventitious shoots always display equally this same simplicity of internal structure.

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[1] But see Vines' "Students' Text-book of Botany."—"They may be produced endogenously or exogenously (1) from a single epidermal cell, (2) from epidermis and pericycle."

[2] Also *Cuscuta* and *Convolvulus*. See Vines' "Students' Text-book of Botany," p. 190—"When the part is very young the adventitious member is developed exogenously; when the part is older the adventitious member is developed endogenously, usually from the pericycle, but sometimes from still deeper tissues."

Finally, there are species whose individual evolution is very slow, and in which the vegetative organs of the young plant, especially its leaves, have a juvenile aspect so pronounced that they entirely differ from those of the adult plant. This may, moreover, manifest itself in two ways. Generally the most developed leaves of the young plant, those that I shall call henceforth the juvenile leaves, are in shape and internal structure simpler than the leaves arising later on the adult plant. But there are also species in which it is, on the contrary, the adult plant which presents the least complicated vegetative organs, as one sees, for example, in the phyllodes of Acacia. Therefore, in either case, the adventitious shoots of the adult plant are always in the beginning leaves of the juvenile form.

This general characteristic of adventitious shoots has been for a long time unrecognised. Schacht seems to me the first who has mentioned it. One finds in his *Traité** a short passage in which he speaks of it *àpropos* of the Canary Island Pine. However, many other trees, and some of the most common in Europe, furnish still more striking examples of this phenomenon. Also it is singular that there is no question either in the *Morphologie* of Hofmeister, nor even in the Memoir of Alexander Braun on the *Individu Vegetal*. This characteristic trait of the adventitious shoots is similarly entirely passed over in silence in modern treatises. Yet, moreover, an eminent Italian botanist, the late G. A. Pasquale, had long ago specially called the attention of morphologists to it. This is how he expresses himself on the subject in his memoir on heterophylly (*Sulla Eterophylla*, p. 22), which appeared at Naples in 1867 :—

"In the course of all these generations of buds and shoots which succeed each other indefinitely on the arborescent plant, one would not again see the forms of the youthful stage, if it did not reproduce in indeterminate points of the axis another sort of bud, which strongly resemble the young plant, and which produce its form and even its colour. These are the adventitious buds which in Pines show themselves freely on the trunk and even on the branches. These adventitious buds enclose the new shoot, which repeats the primitive form of the young plant in everything that it has produced above its cotyledons. It is seen, therefore, that every time one finds juvenile branches with their special leaves on an adult tree or a large one, or even an old one, that this is the result of the accidental formation of adventitious buds. And this phenomenon, the cause of which resides in the plant, can also be produced at will by methods which tend to cause the formation of adventitious buds similar in shape and all other characters belonging to the free development of the trunk and branches. So that, if one wishes to see the juvenile forms reproduce themselves on a tree, one has only to cause adventitious buds to shoot. Similar cases to those I have quoted are seen in *Schinus*, *Eucalyptus*, *Pinus*, &c."

Further on the author adds this remark, to which I shall have to return :—"In the very small adventitious buds of *Æsculus Hippocastanum* are found leaves with three leaflets; that is to say, of simpler form than in the plantlet resulting from germination."

The quotations from the memoir of Pasquale show with what perspicacity and neatness of expression this scholar had recognised and shown the special nature of adventitious buds, and the exact position that they occupied in the ontogenic development of the plant. This memoir is not less remarkable and instructive, because of the rational method with which he treats of what has been improperly called Vegetable Metamorphosis. When, fixing on the study of the internal study of leaves, I myself studied later this supposed metamorphosis as a fact of heterophylly, due to the unequal development of the phyllomes,[1] I was then ignorant that this same idea was already expressed in the memoir of Pasquale. The correctness of this point of view is to-day proved, thanks to the observations and experience of Herr Goebel. Indeed, by an ingenious application of the pruning, not only of the vegetative axes, but also of their appendicular organs, he has succeeded in causing an increase of development in the phyllomes, which, according to their position on the plant, should have maintained the rudimentary state of the bud scales and caused them to assume the forms of true leaves.[2]

To return to the memoir of Pasquale, it is indeed a pity that this masterly work has not received the attention of contemporary botanists. One might almost say that it has been passed almost unnoticed, for the too brief review of it in the *Bull. de la Soc. Botanique de France*[3] does not truly give an idea of its real value.

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* *Handbuch* v. 2 p. 11. This is the translation of the passage in question :—"While our fir-trees never produce adventitious buds, many of those in America are remarkable for the facility with which they produce them. And even in the case of the beautiful Canary Island Pine (*Abies Canariensis*), when the branches have been removed, the trunk is covered with young shoots which have, like the young plants of the ordinary firs, long leaves, in the axils of which there grow later three needles in one sheath.

[1] *Mem. Soc. Phys. et Hist. nat. Gen.* t. xxvi, 2, 1879, p. 453. *Vol. Cent.* 1890, p. 30.

[2] "Beitrage zur Morphologie und Physioldes Blattes." *Botan. Zeit*, 1880, p. 803.

[3] Tome xiv, 1867, p. 153.

Since then it does not seem to have been noticed by anybody, except, perhaps, by Herr Goebel, who quotes it *apropos* of a special case of heterophylly.[1]

To my regret this memoir was still unknown to me, when, several years ago, I made my first communication on adventitious buds.[2] The facts that I then put forth I should admit to-day, were only the confirmation of opinions previously set forth by the Italian scholar. It is the same with the analogous observations made by Prof. Bayley Balfour when he was staying on Rodriguez Island. Having been specially struck by the reappearance of juvenile forms on the adventitious shoots of certain shrubs, he devoted the following lines:—

"The most striking note of variation in the vegetation of the Island, and it is worth attention, consists in the difference of shape and aspect which the leaves of certain species have in the different periods of the growth of the plant. This variation is seen almost solely in trees or shrubs, with the exception, however, of a Composite of small size, *Abrotanella*. In species endowed with this heteromorphism, the young plant produces leaves having, as it were, a degree of development less than those of the leaves of the adult plant, and from the time that the latter reaches this period of its growth, it only produces leaves of the adult form. But, if adventitious shoots arise at the base of the trunk, or even higher, below the first branches, the leaves of these shoots always have the juvenile and not the adult form.

"Further, if young shoots arise from the trunks of mutilated or pruned trees, the latter also bear, as if it were foreseen, the leaves of the juvenile form. An interesting point to clear up would be to determine if shoots arising from a branch treated in the same way would have juvenile or adult leaves, and how far it would thus produce variations in the foliage. It seems to me that there is here a field of interesting observations and experiences of a kind to fix the attention of those who will have opportunity to devote themselves to research of this kind."

The author then enumerates up to seventeen species of Rodriguez in which he has indicated a very marked heterophylly.

Moreover, Dr. Balfour has perfectly recognised the distinctive feature of adventitious shoots, and it is a pity that he is content to describe it incidentally in a floristic work in which it had every chance of being lost to morphologists. If Dr. Balfour had himself pursued the study of the question, he would not have been long in finding, quite within his reach, numerous examples of facts similar to those that he had observed so well in Rodriguez Island. That is what has happened to me many times during the last few years, and I am going to review in turn all the species which have been the subject of my observations.

He then proceeds to give illustrative particulars concerning *E. globulus* and *E viminalis*. See pp. 58–9. (C. de Candolle, *Archiv. des Sciences Phys. et Nat.*, xvi (4), p. 50, July, 1903; translation by J.H.M.).

[Much of this valuably supplements my notes on the relations between the vegetative form and the flowering period, as given at p. 273, Part XLIX.]

7. RINGBARKING.

There is a vast field for inquiry into the best methods of destroying tree-growth. It is a matter of everyday knowledge that trees are sacrificed unnecessarily, but, when it is decided what trees are to be destroyed, there is frequently serious trouble owing to the suckering of certain species (or the ground being taken possession of by others whose seeds have been lying dormant in the ground). The result, from whatever cause, is that ground is taken possession of by scrubby growths which have frequently become well nigh impenetrable, and instead of ringbarking having resulted in an increased growth of grass, the reverse has been the case. So diverse are local conditions that it is impossible to prescribe with exactness the time for destroying trees in every district.

[1] "Organographie der Pflanzen," p. 145

[2] *Arch. des. Sc. Phys. et Nat* t. viii, 1899.

If it be thoroughly understood that trees of different species do not perform their various functions connected with rest and growth simultaneously, and that our seasons are exceedingly irregular compared with those of Europe, on the recorded experience of which many of us rely, perhaps too much, we shall have learned a good deal. And let it be further noted that we have a good deal of pioneer investigation to do yet—in other words, that when a man asks us the best time to ringbark a certain tree, we have frequently no precedent to offer him. Because Stringybark was successfully ringbarked at one place in September, 1911, it does not follow that Box may be successfully ringbarked at the same or any other place in September, 1921. If we could prepare a column of statistics in this way, just as we record physical constants, what a boon it would be! No, we must approach this subject, the importance of which is still of such magnitude to Australians that outsiders can scarcely understand, in another way. We must consider the tree as a living organism, and give some attention to the physiology of tree-growth.

The first thing is to ascertain when the sap is " up " (to use a rather loose phrase, the meaning of which is, however, well understood in practice), evidence of which is shown by the facility with which the bark strips, and also by the formation of the leaves, to be noted at a distance by their greater greenness or freshness of colour, often of a shade of purple. (In Australia we have, of course, mainly to deal with non-deciduous trees, but, nevertheless, it is usually an easy matter for a careful observer to note the extent to which the flush or formation of a new growth of leaves has extended, or whether the tree is at rest.) For an account of the physiology of the processes connected with sap-movement, I must refer to the text-books. But I may remind my readers that starch is contained in the sap of trees, or a substance from which starch is obtained. This starch is separated from the sap and is stored up, during the period of active growth, in the wood, and especially in the rootwood, ready for the formation of buds (usually leaf buds), which buds usually burst in the spring, but the season of bursting forth is exceedingly variable with various trees, as I have already hinted. Every forester, every man concerned in the procuring of timber, and every pastoralist, should make and preserve records of the periods of " flushes " of leaves on each of the various kinds of trees in his own district. Considerable success has attended the ringbarking of trees as they come into flower. The trees are very vulnerable then.

Now, many trees, if the bark be injured or ringbarked, have the power of developing the latent buds (these buds may develop from mere exuberance of sap, without the tree having been visibly injured) which exist under the bark, which buds are developed by means of the store of starchy matter which we have already referred to as existing in the rootwood (and in the stump). In other words, we have " suckers "—those curses of the forester and pastoralist.

So here, as pointed out by Farrer and others many years ago, we have, I think the key to the problem of ringbarking. If a tree is to be rung, see that the work is done properly—right through the cambium layer all round. Then see that it is cut at a period when the particular kind of tree operated upon has little or no starch or bud-sustaining material left in its roots. In other words, see that it is cut off from its base

of supplies. Consequently, it may be bad practice to set a man to indiscriminately ringbark an area. Ringbarking is, in fact, an operation requiring scientific direction, and no landowner should turn a number of axemen into his property to ringbark without very cautiously directing their operations.

It is a pity that the operation of ringbarking should be more difficult than is usually supposed, but we cannot contravene nature's laws without taking the consequences.

8. COPPICE-GROWTH (SUCKERING.)

Coppice-shoots are what Australians know as "suckers," and it is obvious that, whereas suckers of worthless trees are a curse to the pastoralist and perhaps to others, suckers of useful trees may be valuable to the forester from the points of view of the production of timber and of leaves for oil.

Hutchins ("Discussion on Australian Forestry," p. 91) has some notes on Western Australian species. He says :—

> The coppicing power of the different species of Eucalypts, by which I mean their ability to shoot from the stump when cut, is a subject which will be more studied with the advance of systematic forestry in Australia. Karri (*E. diversicolor*) seems to coppice well, Jarrah (*E. marginata*) fairly, and Red Gum of Western Australia (*E. calophylla*) very well. I have seen stools up to 3 feet in diameter shooting freely and vigorously. Yate (*E. cornuta*) is said to coppice readily, but not so strongly as the Red Gum, with which it is associated. This might account for the patchy distribution of Yate, for a great deal of shooting in the natural forest takes place from more or less badly-burnt trunks. Here, again, it should be noted that a tree will often coppice when cut, but fail to coppice when burnt. Appearances seem to indicate that Yate does not shoot again so easily as many species when the forest has been burnt. Thus, the effect of fire protection may be to bring in more Yate. It is certain that Yate does coppice fairly freely, since I have seen large old stools, or the remains of them, with three or four big trees growing from them.
>
> The coppicing power of all Eucalypts varies with the season. It is best in winter and early spring worst in late summer. Many Eucalypts, if cut in the middle of a dry summer, will die straight away, or shoot badly with the return of better weather. Brushing off the shoots, as by cattle, will often destroy young copse. If the shoots are systematically knocked off, the stool will inevitably die. This has to be remembered in clearing for fire-lines.

The late Sir D. E. Hutchins is quite correct in hinting that but few definite observations have been made in regard to the coppicing proclivities of various species of Eucalypts in Australia. It is a forester's job, and this officer can now systematically record his results far better than he could before the taxonomy of the species was as settled as it is to-day.

Here are a few brief notes on the subject—a mere casual selection from my pocket books :—

E. pilularis has high reproductive power. See Part I, p. 30.

E. gigantea is quoted as "absolutely the best re-afforester in the State." (See my "Forest Flora," Part LXI, p. 6.)

E. populifolia (Bimble Box) becomes a great pest when improperly rung or grubbed, for not only do the stumps sucker freely, but the consequent access of light and availability of plant-food cause abundance of seedlings to spring up, and thus large areas of country may be thrown out of occupation.

The tree suckers freely after having been cut down, both from the stems, but apparently more freely from the roots, when they are damaged by the plough, travelling stock, or vehicles. It emits suckers near the injured part, which may be situated at some distance from the trunk. It also seeds freely, and no doubt what often appear to be suckers are really seedlings.

Oil yielding Mallees, usually found in regions of comparatively low rainfall, are cut over, and the permanence of an area to the oil-distiller depends upon the care with which the coppicing is carried out. I will take some typical Mallees in the Wyalong district, New South Wales, with the view of inviting attention to the research required in this direction from the point of view of the forester. I would like to see inquiries as to the coppicing powers of all Eucalypts carried out by the various forestry administrations of the States and the results carefully co-ordinated.

E. regnans F.v.M.—Mr. D. Ingle, Forester, of Healesville, Victoria, gave the following note many years ago :—

A peculiarity of our Mountain Ash is that if ringbarked, cut off stump high or otherwise, or burnt badly, *i.e.*, the head burnt or scorched off (leaves, I mean), it never throws off suckers or side shoots, but dies right out. I have been observing this fact for two or three years now, and lately have made inquiries from selectors, splitters, and millmen, and I find that no one has known this species to throw shoots under the circumstances mentioned, although they don't seem to have recorded it.

E. fruticetorum F.v.M.—Coppices freely, both from roots and stem. Owing to its suckering proclivities, it is a difficult matter to entirely eradicate it from cultivation paddocks. The New South Wales Forestry Regulations for the cutting of this particular Mallee require that it be cut down close to the ground, the result being that in six months after being cut down it sends forth many young growths, which yield more abundant and richer material for the oil distiller. At 3–4 feet high its growth is rapid. It apparently does not deteriorate, at least rapidly, with coppicing. So favourable has been its development that steps are being taken to plant up certain areas of the district with seedlings.

E. Behriana F.v.M.—The leaves are not used by the oil distiller, although it is very common; its timber is used for rough carpentry and firewood. It coppices freely, either on the stems or from the roots or stools. Owing to its comparatively large size, the removal of the plants from a cultivation paddock appear more complete, no doubt owing to the more thorough measures adopted for eradicating it, either by axe, mattock, or spade. The method adopted in the case of the smaller mallees is more slip-shod, they being usually rolled down and ploughed out, but the larger Mallees cannot be so treated. It was noted in a cleared and deserted paddock that the Mallees were again taking possession, both *E. fruticetorum* and *E. Behriana* seeming to succeed equally well.

E. acacioides A. Cunn.—This is a small tree as a rule, but if cut down it sends forth many new growths from the root, stems, and branches. It is of no value as an oil producer, hence it is not valued. It bears a bad name because of the difficulty of eradicating it from cultivated ground. The usual cutting-down process does no more than increase the number of stems, indicating the real Mallee-like character of the plant. It is even said to be a pest of the district because of its uselessness.

E. oleosa F.v.M.—It has all the characteristics of a Mallee, the stools are usually possessed of 6–8 stems, all very much the same height, 12–30 feet, and about 3–4 inches in diameter. In the district of Yalgogrin there are large areas of this species, most of them less than 10 feet high, and consisting of this species exclusively. It coppices freely after being damaged, both at the roots and stem. It being a large plant as a rule, it has to be rooted out by hand, which, while more laborious, is certainly efficacious—hence but few plants are noted growing in cleared land.

E. radiata, a noted oil yielder of the southern tableland and south coast of New South Wales, suckers freely. So also do *E. dives*, *macrorrhyncha*, *piperita*, *melliodora*, *polyanthemos*, *Stuartiana*, *elæophora*, to take a few species of the southern tableland. But a proper investigation, as quantitative as possible, requires to be made.

Physiological reserve material in a log (Moreton Bay Ash, *Eucalyptus tesselaris*) is illustrated by a paper by the late Albert Norton in *Proc. Roy. Soc. Queensland*, iii, 1886, p. 38, entitled "Notes on a living tree-stump."

In June, 1919, Dr. J. B. Cleland exhibited before the Royal Society of New South Wales a shoot several inches long, which had been taken from an excavated log of *E. trachyphloia*, which had been in use for some years as a water-trough in the Pilliga district.

But these are mere notes, intended to stimulate an interest in the effects of coppicing and of bush fires.

Burrs.

Gnaurs and burrs, or knotty excrescences, are very familar to us on the stems of Gum trees, where they frequently attain an enormous size, having a "nigger-head" appearance. They result from dense clusters of adventitious buds arrested in their growth. A photograph of a large burr on *E. tessellaris* will be shown in due course.

9. TWIST IN BARK.

Under the heading "Twist in Australian Timber," I have brought together certain evidence in my "Forest Flora of New South Wales," Part XLI, p. 15, and have a brief note in the same work, Part LVIII, p. 213.

The twist is the resultant of forces represented by the effect of the sun on the one hand, and the wind on the other. The matter is of economic importance, because, in the vast majority of cases, non-twisted trunks, yielding straight-grained timber, are desired by the timber merchant.

I have, at this place, given the heading "Twist in Bark" because the appearance of the bark is readily seen, and affords a ready indication to the timber expert as to whether the subjacent timber will be twisted or not. So that study of the bark receives additional economic importance.

In our Australian forests, as a rule, the greater bulk of the head of a tree is to the north, *i.e.*, it faces the sun, which rises in the east and longest influences the north. I have known bushmen use this indication of the north when lost or in difficulties.

There are many references to this twist in European, and some in American literature, but few in Australian. One of them is the following, and I invite attention of country observers to the problem, premising that their observations will have permanent value if they collect twigs of the trees observed, in order that their specific identity may be ascertained. I may refer to this Torsion or Twist in Bark and Timber under Meteorology later.

Dr. (J. B.) Cleland contributed a "Note on Twists in the Bark of the Jarrah (*Eucalyptus marginata* Sm.)." Of one hundred trees observed in the neighbourhood of Perth, Western Australia, four showed a decided left twist, sixteen a slight left twist, forty-four were straight, twenty-four showed a slight right twist, nine a marked right twist, and in three the twist was undecided (*i.e.*, irregular). As there appeared to be no indication of a tendency to tree-growth in a spiral direction, the explanation was offered that, when young, a predominant branch probably extended to one or other side, and, being played on by the prevailing wind, caused the young stem to become twisted to some extent. Later such a branch may have died and disappeared. The explanation offered seems to be favoured by the fact that contiguous trees are often twisted in opposite directions. (*Proc. Linn. Soc. N.S.W.*, xxxiii, 291, 1908.)

The twist of the bark of *E. gigantea* is decidedly to the left. See the photo. in my "Forest Flora of New South Wales," vol. vi.

Speaking of the bark of a Gum, Professor A. J. Ewart writes to me, inculcating caution in observation :—

Re twist in *Eucalyptus globulus*, I have not made any special observations, but doubt whether the appearance is not largely an optical effect, as in a climbing plant. In stems which appear twisted the fibres may cross one another in opposite directions, and their inclination is not that of the apparently twisted stem.

But Gums (*e.g.*, *E. tereticornis*), however, do show twist in a marked manner, and I hope that some observer will systematically take the matter up, as far as Australia is concerned.

Mr. J. F. Campbell, the well-known New South Wales surveyor, writes :—

The Eucalypts, as far as I have observed, do not conform to any fixed mode of development as regards their growth curvatures. Spiral twisting is least noticeable within the dense stands of timber or in the brush areas, but the trees which skirt these areas are usually twisted and frequently gnarled. Thinly scattered timber almost invariably show well-defined growth curvature (owing to the lack of shelter from the wind, J.H.M.). The cross-grained character of the Eucalypt is readily seen when logs are split radially. The split surfaces show both dextrorse and sinistrorse growth curvatures alternating irregularly.

My non-Australian references shall be of the briefest.

1. Schlich, v. 39, says :—". . . it is found that those (trees) twisting from left to right (against the sun's apparent course) are harder to split than those twisting in the opposite direction." (He is, of course, referring to the northern hemisphere.)

2. It is also, of course, the direction of the apparent movement of the sun in the northern hemisphere. Some writers (*e.g.*, the Belgian geologist, Van den Broeck) say that the twisted trunks of trees are produced by the earth's rotation, and therefore when they exhibit a spiral they should show a right-hand spiral in the northern hemisphere, and a left hand in the southern, like the turn of the cyclonic storms or the twist in water vortices; but this is still open to more exact observation. It has also been suggested that, as the winds due to the earth's motion blow fairly steadily just when the trees are growing fast, the young trees may take a permanent twist from this cause, which it never loses. ("The Curves of Life," by T. A. Cook, p. 31.)

3. That part which looks towards the north is narrower, and has closer and denser rings than the other.

M. Ch. Musset states that the trunks of trees are always flattened in a northerly and southerly direction, and expand in an east and west plane, a fact which he considers quite in accordance with astronomical laws.

4. A singular uniformity has been observed in the twist of tree trunks. In 990 trees out of every 1,000 whose trunks show torsion, the direction of the twist is from right to left. This accords with the direction of the revolution of cyclonic storms in the Northern Hemisphere, and also with that of whirlpools, which the French *savant*, Jean Brunhes, says almost invariably turn from right to left. The question arises whether in the Southern Hemisphere the torsion of tree trunks has an opposite direction, like the cyclonic motions of the atmosphere in that half of the globe. (A reference, the origin of which I have lost.)

Another quotation from my old friend, Mr. J. F. Campbell:—

5. While engaged in architectural pursuits in Britain I had an excellent opportunity of observing some of the structural characteristics in the growth of the pine timber trees then used in building construction. As regards the growth curvatures of the trunks of these trees and the influences that produced them, I found that practically all scantlings cut from the pines of the Northern Hemisphere as seen and handled by me had a dextrorse twist, which I then attributed to heliotropism. Assuming heliotropism as one of the most potent stimuli to twisting, its effect would or should be somewhat irregular within the tropical regions, but becoming more definite and regular towards the Poles. The pine belt of the Northern Hemisphere has practically no counterpart in the Southern Hemisphere owing to the absence of land surfaces of any extent south of lat. 40. But specimens of, say the South Patagonian pines, should aid in elucidating this interesting subject of inquiry.

10. BARK REPAIR.

The following species possess the power, in a high degree, of bark-repair if a portion be removed from the trunk. The injured bark will also spread, or tend to spread, over any foreign body adjacent:—*E. maculata*, *E. hæmastoma*, var. *micrantha*, *E. tesselaris*, *E. coriacea*. (*Angophora lanceolata* is an even better example, perhaps.)

It will be observed that all these are true Gums, or Smooth-barks, in other words, barks that are full of life, not those which are more or less dead superficially, such as Stringybarks and Ironbarks.

In the case of explorers' and surveyors' marks, a good deal of inconvenience is sometimes caused by the over-growth of the bark, which may completely obliterate the inscriptions.

Callus is the name given to the soft parenchymatous tissue which forms over any wounded or cut surface of a stem. The callus forms a cork cambium on its outer surface. The subject of the growth of the callus over an old wound is dealt with in a lucid manner (with illustrations) by Professor B. E. Fernow in Circular No. 16 of the Division of Forestry, United States Department of Agriculture.

In Mr. R. T. Baker's exhibit of a series of specimens showing traumatic growth in timbers, before the Royal Society of New South Wales, 1st September, 1919, he verbally made the suggestion that Kino flow (in Eucalypts) and the formation of Alumina succinate (in *Orites excelsa*) may have an antiseptic action, thus promoting new growth. This is, of course, an analogy to Listerism in surgery.

11. MICROSCOPIC CHARACTERS OF BARK.

The published references to the microscopic structure of Eucalyptus barks seem scanty in the extreme.

General.—In "Eucalyptographia" (Mueller), under *E. globulus*, we have four sections, labelled as follows:—

1. Tangential section of middle-bark (A), and inner-bark (B).
2. Radial section of a portion of middle-bark (A), and inner-bark (B).
3. Transverse section of a portion of inner-bark.
4. Transverse section of a portion of middle-bark:—

   b. Bast-fibre; *c.* cork-cells; *n.* crystal-cells; *m.* medullary-rays; *p.* bast-parenchyma; *s.* stone-cells (214 diameters).

Solederer even has less to say: "Stone cells, according to Möller, occur in the secondary bast of species of Eucalyptus; the stone-cells attain considerable dimensions in *E. corymbosa*, while in other species they are only slightly sclerosed." (i, 355.)

12. CALCIUM OXALATE.

Calcium oxalate is a very common substance in plants, occurring usually in the form of needle-shaped crystals (raphides) or crystal aggregates.

Calcium oxalate crystals are undoubted excreta, representing by-products of metabolism. Oxalic acid in the free state, existing as a solute in the cell sap, is believed to be poisonous, especially if present in large amount, though in the various Sorrels (*Oxalis*) it is abundant enough to give them their characteristic taste. Even if not poisonous, free oxalic acid certainly is deleterious, since its formation interferes with further cell activity, as does sugar or any other product of metabolism, unless transformed into an insoluble substance or removed to other cells. Thus, the chief advantage of crystals is in removing oxalic acid from solution. Sometimes it is held that crystals are beneficial in removing calcium from solution, especially in calcareous soils, though this view has not met with general acceptance. . . . In most cases it is not necessary or even desirable to seek a subsidiary function for the excreted products of plants; if in certain instances they have such a function, it must be regarded as wholly incidental. (Coulter, Barnes and Cowles, *op. cit.* ii, 626.)

Solederer, i, 352, 355, says that in the Myrtaceæ, oxalate of lime occurs only in the form of clustered and ordinary solitary crystals—in the primary cortex and bast.

In figures of some sections of bark ("Eucalyptographia," under *E. globulus*) Mueller depicts "crystal-cells," but he does not state the composition of the crystals. They are calcium oxalate.

H. G. Smith, in a paper "On the occurrence of Calcium Oxalate in the barks of the Eucalypts" (*Proc. Roy. Soc. N.S.W.*, xxxix, 23, 1905) announces the presence, in large quantities, of calcium oxalate in the barks of several species. It is similar in

form and appearance in all species, being well defined monoclinic crystals, in stout microscopic prisms, averaging 0·0174 mm. in length and 0·0077 mm. in breadth, and containing one molecule of water. A peculiarity of these is the tendency to form twins geniculate in appearance; twinned forms being pronounced in some species. The theory is advanced that some of the " Mallees " or shrubby Eucalypts have been formed through the poisoning effect of the excess of this substance, acting for a long time upon species which originally grew as large trees. The tannins in those Eucalyptus barks containing a large amount of calcium oxalate are of very good quality, light in colour, astringent, easily soluble, and should make leather of good quality. On evaporating the extract to dryness on the water-bath, but little darkening takes place, and the product is still readily soluble.

He goes on to say that this class of Eucalyptus barks should, therefore, make excellent tanning extracts. From the bark residue the calcium oxalate should be profitably extracted, and the oxalic acid obtained cheaply from this, practically as a by-product. The air-dried bark of *Eucalyptus salubris*, the " Gimlet " of West Australia gives 30·5 per cent. of total extract and 18·6 per cent. of tannin absorbed by hide powder and contains 16 per cent. of calcium oxalate. The bark of *E. gracilis* contains 16·66 per cent. of calcium oxalate; that of *E. Behriana*, 16·5 per cent.; of *E. oleosa*, 10·64 per cent.; of *E. dumosa*, 9·8 per cent.; and of *E. salmonophloia*, 8·34 per cent. The barks of all the Eucalypts tested contained calcium oxalate, although in some species in very small amount.

" The Mallees which contain the crystals in greatest abundance seem to be those species which have a very thin, smooth bark."

" *E. salmonophloia* and *E. oleosa*, being apparently the same tree in different forms of growth, it is probable that the latter is a stage in the slow, and permanent degeneration of the larger tree " (p. 26).

" The form of calcium oxalate peculiar to Eucalyptus barks contains one molecule of water, and has the composition and crystalline form of the mineral Whewellite, with which substance it is perhaps identical." (p. 26.)

Mr. Smith found percentages of calcium oxalate in the following barks :—

E. gracilis, 16·66.

E. Behriana, 16·50.

E. salubris, 16·00.

E. oleosa, 10·64.

E. dumosa, 9·80.

E. salmonophloia, 8·34.

E. occidentalis, 6·82.

E. viridis (*acacioides*), 5·01.

E. redunca, 4·46.

E. fruticetorum (*polybractea*), 2·14.

E. stricta, 0·69.

E. Morrisi, 0·08.

The substance occurs also in *E. pumila.*

13. TANNIN.

Tannin is another waste product, and reference has already been made to it in Mr. H. G. Smith's remarks concerning calcium oxalate.

> Most tannins doubtless are waste products, and eventually they are removed through the exfoliation of the bark; similarly, exfoliation rids trees of many other waste products that accumulate in the bark, such as alkaloids, gums, resins, and calcium oxalate. Tannins, because of their bitterness, may be useful incidentally in protecting from animal depredations; some tannins, known as plastic tannins, probably are of value in nutrition. Tannin production appears to be especially characteristic of xerophytes, desert plants growing in mesophytic conditions have much less tannin than in their natural habitat. (Coulter, Barnes, and Cowles, *op. cit.* ii, 724.)

See also "An investigation of the Barks of four Western Australian Species of Eucalyptus," by H. G. Smith, *Journ. of Agriculture*, Western Australia, April, 1905, p. 219. This investigation was undertaken to determine the value of these barks for tanning purposes. The species are *salmonophloia, salubris, redunca,* and *occidentalis.*

While some analyses have been made of Eucalyptus barks for tannin, only one variety, perhaps a good species, *Eucalyptus occidentalis* var. *astringens* Maiden, the "Mallet" of Western Australia, has been put to commercial use. In this connection see Part XXXVI, p. 143. See also D. E. Hutchins' "A Discussion of Australian Forestry," p. 239 (1916).

Mr. C. E. Lane-Poole, Conservator of Forests of Western Australia, is giving attention to the potential value of the tan-bark value of *E. platypus* and other species.

The consolidated barks, which include the Gums, and, to a certain extent, the Ironbarks, contain more or less tannin in the form of kino; the fibrous barks contain it least, in proportion, as the differentiation into fibre has proceeded.

14. OIL IN BARK.

A correspondent (Mr. E. H. F. Swain) states that the inner bark of *E. acaciæformis* has a distinct odour of turpentine, and hence the tree is sometimes known as Turpentine. The bark of old trees of *E. aggregata* contains essential oil. As regards oil in the bark of *E. cinerea,* see Part XXIV, p. 72. See a paper "On the Essential Oil from the Bark of *Eucalyptus Macarthuri*," *Journ. Roy. Soc. N.S.W.*, l, 177, 1916, by H. G. Smith. "The oil from the bark of this species agrees with that distilled from the leaves. It is equally rich in geranyl-acetate, and need not be kept distinct from the leaf oil."

There is no doubt that search will bring to light oil in the barks of other species.

15. FIBRE IN BARK.

In the Official Record, Intercolonial Exhibition, Melbourne, 1866–67, p. 248, are the results of experiments in paper-making with the barks of *E. obliqua, rostrata. amygdalina* (*radiata*), *globulus, goniocalyx, corymbosa, leucoxylon, longifolia, Stuartiana.*

In *Agric. Gazette, N.S.W.*, February, 1902, will be found a paper by me entitled "Some Australian Vegetable Fibres," which gives a short bibliography of the subject, and briefly refers to a few species. *E. amygdalina* (probably *E. numerosa* was chiefly meant, for *E. amygdalina* was very comprehensive in 1902), when I quote: "The inner bark is adapted for the manufacture of coarse paper, and the same may be said of many other species."

Then certain Stringybarks (*capitellata, eugenioides, macrorrhyncha, Muelleriana*) were referred to. The chief use of the bark is, when removed in large sheets, for roofing purposes, and also for the walls of settlers' huts, also of outhouses. The inner layers are used for hay-bands, and for other uses where a coarse tying material is required. *E. capitellata* is quoted for door-mats.

A figure of a basket (Bee-lang), showing good workmanship, and made by Yarra natives out of this fibre is in Brough Smyth's "Aboriginals of Victoria," i, 344. A few more notes will be given later when Aborigines and Eucalyptus are referred to.

In a paper, "Indigenous Fibrous Plants of Victoria," *Vict. Journ. Agric.*, October, 1918, p. 600, J. W. Audas quotes the bark of certain Eucalypts as "suitable for the manufacture of packing and, probably, printing paper . . . coarse paper . . . strong wrapping-paper . . . paste-boards."

In a paper in the same Journal, December, 1918, p. 747, Professor A. J. Ewart corrects some loose ideas on the subject, and following is part of what he said :—

As the term "fibre plant" has been used in a misleading sense, it may be as well to define it more exactly. Fibres are as much an essential part of the structure of a flowering plant as bones are of a vertebrate animal, so that a list of the fibre plants of Victoria would be merely a list of the flowering plants of Victoria, and would include the ferns and their allies also. The term can, however, be restricted so as to include only those plants whose fibres have been proved to have a definite commercial value as sources of fibre. From this point of view no plants native to Victoria have become recognised fibre plants. A number of the more promising were tested by Mr. Guilfoyle and others many years ago and the fibres extracted, but none of them has been able to displace any of the recognised sources of fibres. To be able to do this, a new fibre plant must satisfy various conditions, which may be detailed as follows :—

1. Its fibres must be easily capable of separation and purification.
2. They must be equal or superior in strength, length, and quality to the class of fibre with which they have to compete.
3. They must be present either in unlimited quantity, or must come from plants which are capable of cultivation.

The exploitation of a fibre plant means a factory, and a factory cannot be dependent upon a precarious or quickly exhausted supply of a wild plant. If the fibre of the latter is sufficiently valuable commercially, the plant is worth cultivating to secure a constant supply, and it must then compete with easily cultivable plants, such as flax, &c. Further, in a country where thousands of tons of straw are burnt annually, not out of wastefulness, but because the price obtainable for the whole yield would not cover the cost of collection and transportation, there is no need to search among wild plants for materials for strawboard or coarse paper pulp.

The plant fibres of use commercially fall into three main classes. There are, firstly, the fibres termed "pappus," which are hairs growing usually from seeds enclosed in pods (cotton, kapok, &c.). No native plant shows any likelihood of being able to displace any of the plants recognised as sources of this type of fibre. The combination of strength, length, and purity in the cotton fibre is unique among plants.

In the second class of fibre plants, the fibres belong to what is termed sclerenchyma tissue, and in Dicotyledons they occur just outside the vascular bundles (veins) in a herb, or in the bark outside the wood in a tree. In Monocotyledons, however, the fibres are usually associated with the vascular bundles which are scattered all through the stem or leaf, and do not occur on the outside of the stem only. As a general rule, therefore, in Dicotyledons this class of fibre is more easily obtained in pure form than in Monocotyledons, where it is associated with the wood tissue and soft, weak, easily decomposed phloem tissue of the vascular bundle. The finer fibres of this type are, therefore, obtained from Dicotyledons (flax, hemp, jute), for the most part. Monocotyledons yield coarser, weaker, darker, or more irregular and rougher fibres of less commercial value (coir, raffia). New Zealand flax (*Phormium tenax*) is one of the few exceptions, but is at a disadvantage owing to its slow growth under cultivation.

The third class of fibre is derived from the fibres of wood tissue, and, as a general rule, is employed only for making paper pulp, but has been used in various ways in Germany for weaving to make good the deficiency of proper textile fibres. For wood pulp the fibres should be at least 1 to 4 millimetres long, they must be easily separated by mechanical or chemical treatment, and must, therefore, not be too strongly cemented together, and the less lignified the fibres are, and the more they consist of unaltered cellulose, the better.

Bearing the above facts in mind, it may be worth while to consider how far the native plants which have been put forward as fibre plants comply with the above conditions and requirements as possible commercial sources of fibre.

Eucalyptus Barks as Fibre-yielding Barks for Paper-making.—The first statements to this effect appear to have been made some thirty years ago by Baron von Mueller, and apparently were intended as statements of possibility rather than as statements of fact. Since then, owing to the increased use of wood pulp for paper-making, many once promising materials have lost all value for this purpose. The original statements have, however, been repeated again and again more and more dogmatically without further investigation of the actual economic value of such materials.

In some respects the barks of Eucalypts have precisely those qualities which should not be present in good paper-pulp materials. Thus the presence of insoluble gum, resin, or kino, or of a high percentage of tannin or colouring materials is a serious disqualification for paper-pulp purposes. The pulp must be capable of ready bleaching without treatment so severe as to damage the fibres, lessen their strength, or cause their walls to swell. Finally, the bark must not contain suberinized tissue mixed up with the fibres, as is the case with the stringy barks. The suberinized tissue is more resistant than the fibres to caustic soda and retting, and can only be removed even partially by expensive mechanical methods. Until it is removed a satisfactory pulp cannot be obtained.

Statements as to the value of the barks of Eucalypts for paper-making should, therefore, be received with great caution, unless definite evidence is given of the actual manufacture, cost, and quality of the paper supposed to be yielded by them.

Eucalyptus obliqua.—The bark is stated to be suitable for the manufacture of packing, printing, or even writing paper, as well as for mill and paste boards, and the pulp is stated to bleach readily. As a matter of fact, the fibres are red or brown in colour, are very weak, and cannot be bleached readily by any cheap method without still further weakening them. As the bark contains large amounts of suberinized non-fibrous tissue, it is unsuitable for paper-making. The same applies to *Eucalyptus macrorrhyncha*, the red stringy bark.

The barks of *E. globulus*, *E. amygdalina*, *E. radiata*, *E. goniocalyx*, *E. corymbosa*, *E. longifolia*, *E. Stuartiana*, and *E. rostrata*, are also stated to be useful in or suitable for paper-making. I have not been able to procure any samples of paper made from these barks, nor can I find any data as to the cost and value of paper prepared from them. They all appear to have one or more disqualifications as economically valuable sources of paper-making materials, and hence, until precise information in regard to them can be brought forward, including cost of treatment and value of product, they can be dismissed from the list of materials suitable for paper-making.

In the "Australian Forestry Journal," March, 1921, p. 84, there is a note on "Rope from Jarrah Bark" (*E. marginata* Sm.) In Western Australia there are great accumulations of this at the mills, and experiments are going forward with the object of

utilising the inner bark, which has some tenacity, in the direction indicated. If a cheap method can be devised, it will doubtless be applied to the inner fibre of many other species, utilised already as a rough tying material.

The bark of *E. sideroxylon*, grown in South Africa, is being tested as an insulating medium in cold-storage work, see " The South African Journal of Industries," March-April, 1921, p. 271. The fibre of this species has properties in the direction of corkiness or non-conduction of heat, rather than that of tenacity of fibre.

16. COLOUR OF INNER BARK.

The inner bark in Eucalyptus may, when quite fresh, be quite pale-coloured, (" white,") yellow, of various degrees of intensity, to orange, and even brown and red. These colours are probably due to tannins, and, particularly as regards the yellows, it would be desirable to invoke the aid of the chemist.

The bright yellow of the inner bark of *E. melliodora* is so characteristic that the name of the tree is " Yellow Box " because of it, and one chips off a little of the bark with a tomahawk in all cases of doubt. I remember, at a time that *E. Bosistoana* was but little known, and its range far less worked out than it has been since, coming across a tree in the Liverpool district (N.S.W.) called " Yellow Box." A chip showed the inner bark to be non-yellow, and therefore it could not be *E. melliodora*. It turned out that it was known as Yellow Box because of the yellowish colour of the wood, but the colour of the inner bark at once showed the difference between it (*E. Bosistoana*), and the original Yellow Box (*E. melliodora*).

I have a note in regard to the yellow inner bark of *E. Muelleriana*, the stain sometimes penetrating through the wood, at Part VIII, pp. 220 and 236. Other Stringybarks, perhaps all of them, have yellow inner barks, *e.g.*, *E. capitellata*, *E. macrorrhyncha*, *E. eugenioides*, *E. lævopinea*. *E. cladocalyx* has a thick, sappy bark of a rich orange colour.

E. acacioides has an inner bark of an orange colour, but I do not know whether this colour is practically constant. I feel in this, as in so many other aspects of the big subject of Eucalyptus, I am but offering a pointer to others. We want the accumulation of facts, and then we can group them and, later on, make deductions concerning them.

17. COLOUR OF OUTER BARK.

These notes on colours apply only to the Gums, and they vary to some extent with locality and season of year. For further notes on colours see under *E. stellulata*, *pumila*, *Bœuerleni*, *Behriana*. In all these species we have greenish barks at one season or another. Sometimes they are oily green, and sometimes olive green, and sometimes shade off into a lead colour.

E. hæmastoma also sometimes exhibits a brown colour, and so do the Grey Gums (*E. punctata* and *E. propinqua*). The Gums display a variety and intensity of colour during the year, and in different years, and I regret I have not brought my notes on the subject together.

The following passages from a standard American work may be useful :—

Young bark commonly is green, because the cortical chlorophyll is evident through the transparent epidermis. Soon the stem ceases to appear green; the chief cause of the change in colour being the development of the cork layer, whose opacity makes the chlorophyll invisible. The common bark colours are grey, brown, and black; but red occurs, as in some Dogwoods (*Cornus*), and white, as in some Birches (*Betula*). As the tree matures the characteristic bark colour may be seen only on the young branches, if the older limbs are furrowed.

In a few cases, as in the Mistletoe (*Phorodendron flavescens*), Moonseed (*Menispermum*), Sassafras (*Laurus Sassafras*), and Greenbrier (*Smilax rotundifolia*), the relative freedom from cork formation permits the green colour to remain evident longer than usual. Such green-stemmed trees as the Bamboo and the Banana are in reality gigantic herbs, in which ordinary bark does not develop.

Often the exterior and the interior of the bark are differently coloured, as in the Hemlock (*Tsuga*), where it is black without and red within, and as in the Yellow-barked oak (*Quercus tinctoria*), which is named from its inner bark, the outer bark giving rise similarly to the name Black Oak (*Quercus Robur*). Bark colours, especially interior colours, often are due to the presence of various excreted products, such as the Tannins. Advantages in the various colours are not to be looked for. (Coulter, Barnes, and Cowles, *op. cit.* ii, 708.)

Glaucousness.

Some Eucalypts have glaucous branches, the rest of the plant being mainly non-glaucous, *e.g.* :—*E. Andrewsi*, *E. Considenіana*, *E. gigantea*, *E. obliqua*, *E. sepulcralis*, *E. Sieberiana*. This hint is sometimes useful in the forest.

" Powder-barks," in Western Australia, are tress with smooth barks with more or less glaucous appearance (they are allied to the preceding), but the glaucousness more or less covers the whole of the trunk, and is so abundant that it is easily removed by friction, *e.g.*, by human clothing. Such species include—

E. accedens;

E. Lane-Poolei;

E. microtheca (of Cue), that form of the species which is abnormal in the volume of its glaucousness.

The subject is more or less bound up with that of glaucousness in leaves, and will be referred to when leaves are dealt with.

Explanation of Plates (212-215).

PLATE 212.

x *E. algeriensis* Trabut.

1*a*. Flowering twig; 1*b*, buds and flowers; 1*c*, umbel of fruits; 1*d*, fruits viewed from the top. All reproduced from *Bull. de la Station de Recherches Forestières du Nord de l'Afrique*, Vol. 1, Plate 12 (Trabut).

2. Juvenile leaves from No. 221, Herb. d'Algerie, received from Dr. Trabut, in National Herbarium Sydney.

x *E. antipolitensis* Trabut.

3*a*. Juvenile leaves; 3*b*, mature leaf; 3*c*, buds; 3*d*, two views of fruits. Note that the buds and fruits are angled, and in threes. Reproduced from the same bulletin as *E. algeriensis*, but Plate xv *bis*.

PLATE 212—*continued.*

x *E. Bourlieri* Trabut.

4*a*. Juvenile leaf; 4*b*, mature leaf; 4*c*, leaf and buds; 4*d*, leaf and flower; 4*e*, buds; 4*f*, fruits. All from the same bulletin as *E. algeriensis*, but Plate 13.

5*a*. Front and back views of anther; 5*b*, hardly ripe fruits, sessile on a flattened pedicel. Both from a specimen furnished by Dr. Trabut.

PLATE 213.

x *E. Cordieri* Trabut.

1*a*. Juvenile leaf; 1*b*, mature leaf, with fruits; 1*c*, buds. All from the same bulletin as *E. algeriensis*, but Plate 15.

2*a*. Buds; 2*b*, fruits. Drawn from No. 243, Herb. d'Algerie, from "Collection Bourlier, Alger" (Dr. Trabut). Apparently identical with No. 16 (one specimen) and No. 241.

3*a*. Buds and flower; 3*b*, fruit. Drawn from No. 237 of the same herbarium, det. Trabut, and bearing a note, "Hybride de *globulus*, dans un semi de *Risdoni* ? Echantillon provenant de M. Cordier et determine par lui hybride de *globulus*, 1865."

x *E. Trabuti* H. de Vilmorin.

4*a*. Large mature leaf; 4*b*, twig with buds; 4*c*, twig with fruits; 4*d*, two views (enlarged) of a fruit. All from same bulletin as *E. algeriensis*, but Plate 11.

5*a*. Buds; 5*b*, fruits; both smaller than the type. Both drawn from No. 192, Herb. d'Algerie (Jardin Botanique de l'Université), det. Dr. Trabut.

6. Fruits, more cylindrical and with longer pedicels than the type. Drawn from No. 193, Herb. de l'Algerie.

PLATE 214.

x *E. gomphocornuta* Trabut.

1. Reproduced from Révue Horticole, 1903, Fig. 128, p. 326 ("Quelques Eucalyptus hybrides dans la region Mediterranéene"). Type.

2*a*. Buds; 2*b*, fruit, of *E. gomphocornuta*.

3*a*. Buds; 3*b*, fruit, of *E. gomphocephala*.

4. Buds of *E. cornuta*. (4*a* has been admitted in error.) (Nos. 2, 3, 4 reproduced from Fig. 3, p. 148, of *Bull. de la Stat. de Rech. du N. de l'Afr.*)

Nos. 3 and 4 are the parents of the two species in the Algerian plantation which cross-pollinated and produced *E. gomphocornuta*, figured at 2 (and also at 1).

5*a*. Juvenile leaf; 5*b*, mature leaf and fruits of No. 51, Herb. d'Algerie, 1904, labelled by Dr. Trabut *E. gomphocornuta*.

x *E. pseudo-globulus* Hort.

7*a*. Buds and mature leaf; 7*b*, fruits. Reproduced from Fig. 5, p. 152, of Dr. Trabut's paper in *Bull. de la Stat.*, etc., already frequently quoted.

It is an undoubted hybrid, but has apparently not yet been formally described.

PLATE 215.

x *E. jugalis* Naudin.

1*a*. Juvenile leaves; 1*b*, mature leaf and buds; 1*c*, buds; 1*d*, truncate anther. No. 8, Herb. d'Algerie (Dr. L. Trabut, 1904).

2*a*. Mature leaf; 2*b*, two different views of fruits. No. 22, Herb. d'Algerie (Dr. L. Trabut, 1904).

x *E. Insizwæensis* Maiden, n.sp.

3*a*. Juvenile leaf, the upper face shiny; 3*b*, mature leaf; 3*c*, mature leaf and buds; 3*d*, front and back view of anthers; 3*e*, fruits. From Insizwa Plantation, Mt. Ayliff district, Cape Province, South Africa (from Chief Conservator of Forests).

The following species of Eucalyptus are illustrated in my "Forest Flora of New South Wales"* with larger twigs than is possible in the present work; photographs of the trees are also introduced wherever possible. Details in regard to their economic value, &c., are given at length in that work, which is a popular one. The number of the Part of the Forest Flora is given in brackets :—

acaciiides A. Cunn. (xlviii).
acmenioides Schauer (xxxii).
affinis Deane and Maiden (lvi).
amygdalina Labill. (xvi).
Andrewsi Maiden (xxi).
Baileyana F.v.M. (xxxv).
Baueriana Schauer (lvii).
Baueriana Schauer var. *conica* Maiden (lviii).
Behriana F.v.M. (xlvi).
bicolor A. Cunn. (xliv).
Boormani Deane and Maiden (xlv).
Bosistoana F.v.M. (xliii).
Caleyi Maiden (lv).
capitellata Sm. (xxviii).
conica Deane and Maiden (lviii).
Consideniana Maiden (xxxvi).
coriacea A. Cunn. (xv).
corymbosa Sm. (xii).
crebra F.v.M. (liii).
Dalrympleana Maiden (lxiv).
dives Schauer (xix).
dumosa A. Cunn. (lxv).
eugenioides Sieber. (xxix).
fruticetorum F.v.M. (xlii).
gigantea Hook. f. (li).
globulus Labill. (lxvii).
goniocalyx F.v.M. (vi).
hæmastoma Sm. (xxxvii).
hemiphloia F.v.M. (vi).
longifolia Link and Otto (ii).
Luehmanniana F.v.M. (xxvi).
macrorrhyncha F.v.M. (xxvii).
maculata Hook. (vii).
Maideni F.v.M. (lxix).
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microcorys F.v.M. (xxxviii).
microtheca F.v.M. (lii).
Muelleriana Howitt (xxx).
numerosa Maiden (xvii).
obliqua L'Hérit. (xxii).
ochrophloia F.v.M. (l).
odorata Behr and Schlectendal (xli).
oleosa F.v.M. (lx).
paniculata Sm. (viii).
pilularis Sm. (xxxi).
piperita Sm. (xxxiii).
Planchoniana F.v.M. (xxiv).
polyanthemos Schauer (lix).
populifolia Hook. (xlvii).
propinqua Deane and Maiden (lxi).
punctata DC. (x).
radiata Sieb., as *amygdalina* (xvi).
regnans F.v.M. (xviii).
resinifera Sm. (iii).
robusta Sm. (lxviii).
rostrata Schlecht. (lxii).
rubida Deane and Maiden (xliii).
saligna Sm. (iv).
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Sieberiana F.v.M. (xxxiv).
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Thozetiana F.v.M. (xlix).
viminalis Labill. (lxiv).
virgata Sieb. (xxv).
vitrea R. T. Baker (xxiii).

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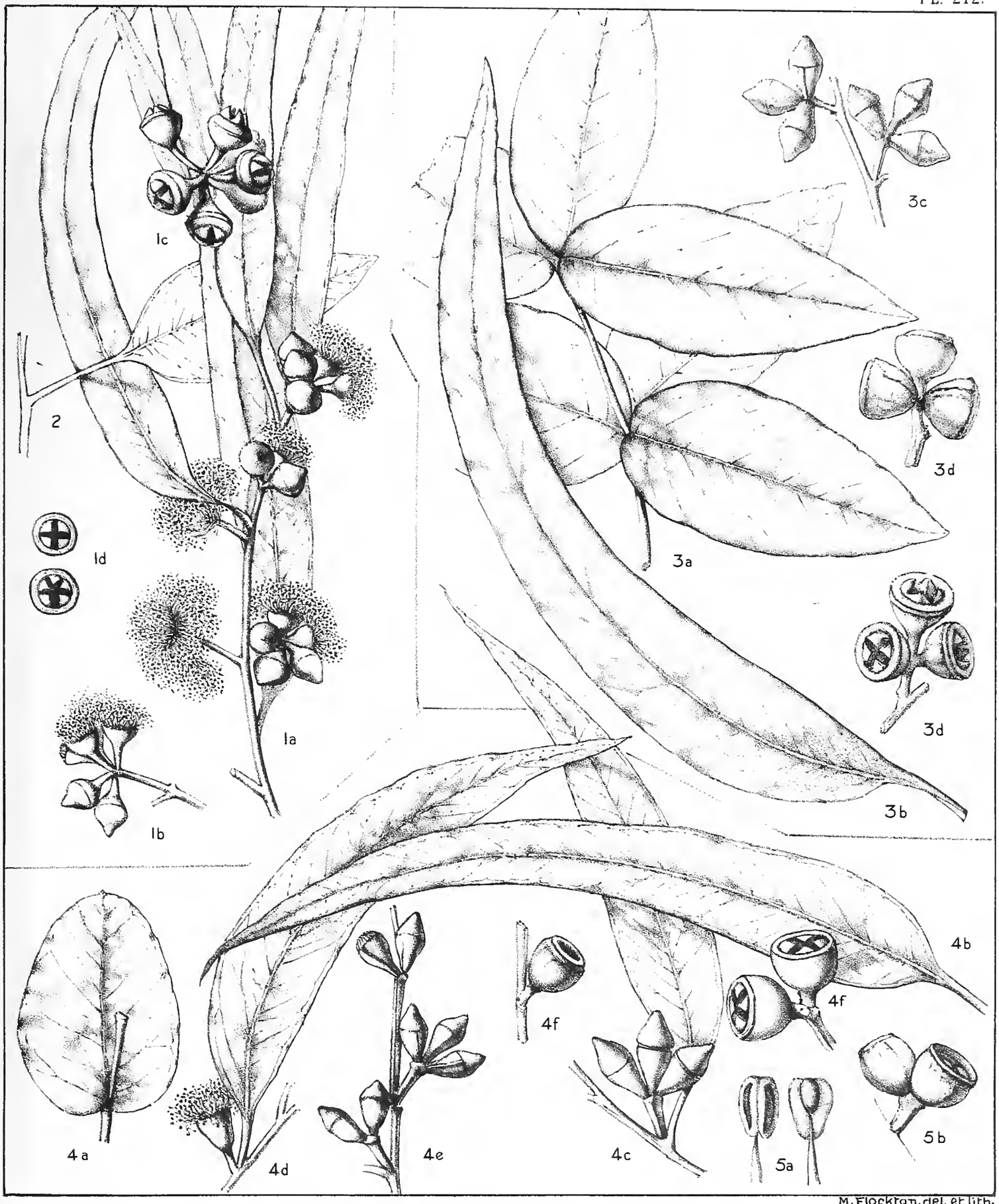
* Government Printer, Sydney. 4to. Each part contains 4 plates and other illustrations.

NOTE BY GOVERNMENT PRINTER.

War conditions have so largely affected publications that it is no longer possible to continue the issue of "The Forest Flora of New South Wales" at the old rates, and from this date onward, *i.e.*, from and including Part 7, Vol. VII, the price of the individual Parts will be raised to 2s. 6d. each.

For those Parts already published the old sale price will be adhered to, and subscriptions already received will not be disturbed, but the new subscription rate of 2s. 6d. per part, or 25s. for 12 parts, will come into effect as from the 1st July, 1921.

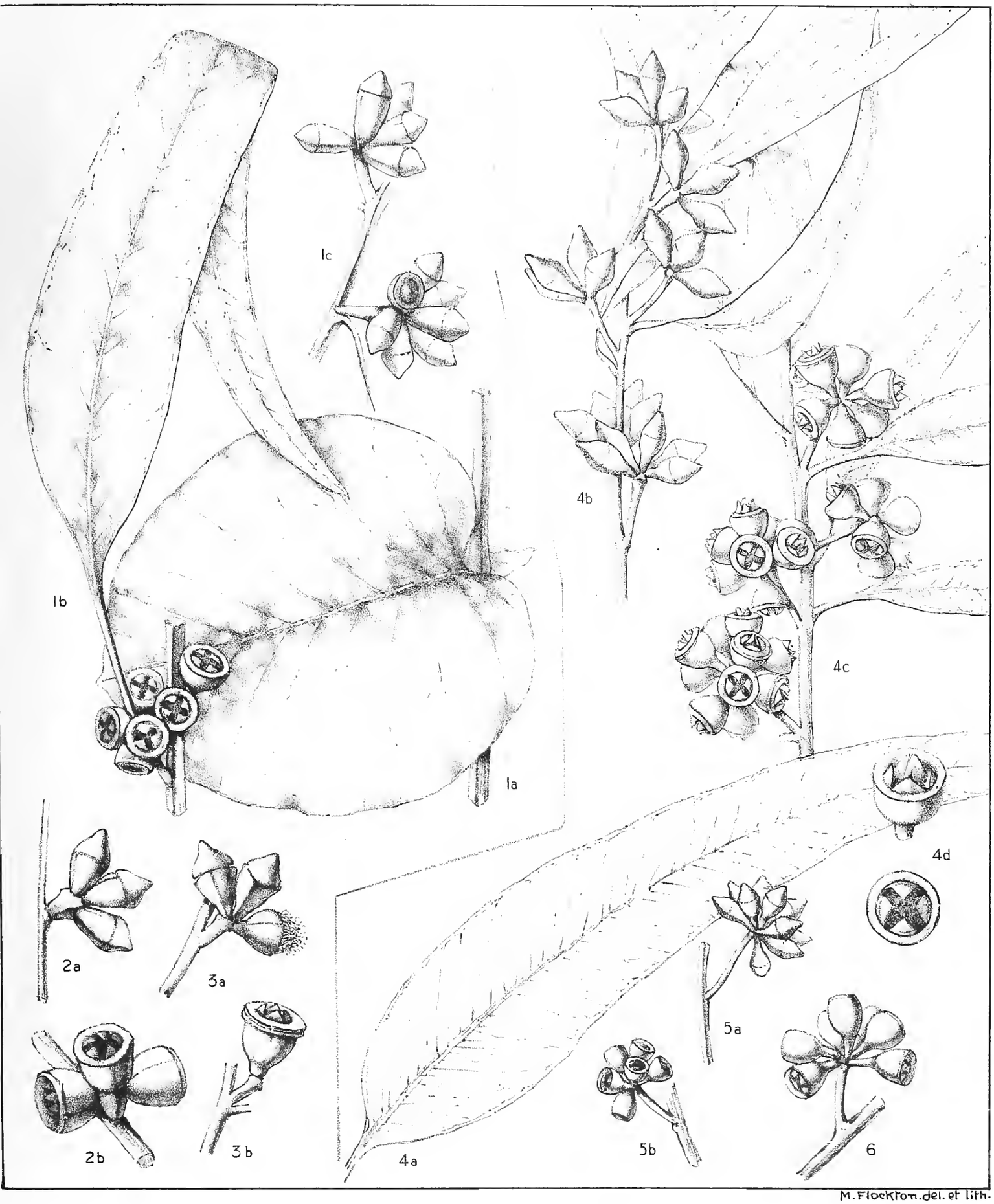
Sydney: William Applegate Gullick, Government Printer—1922.



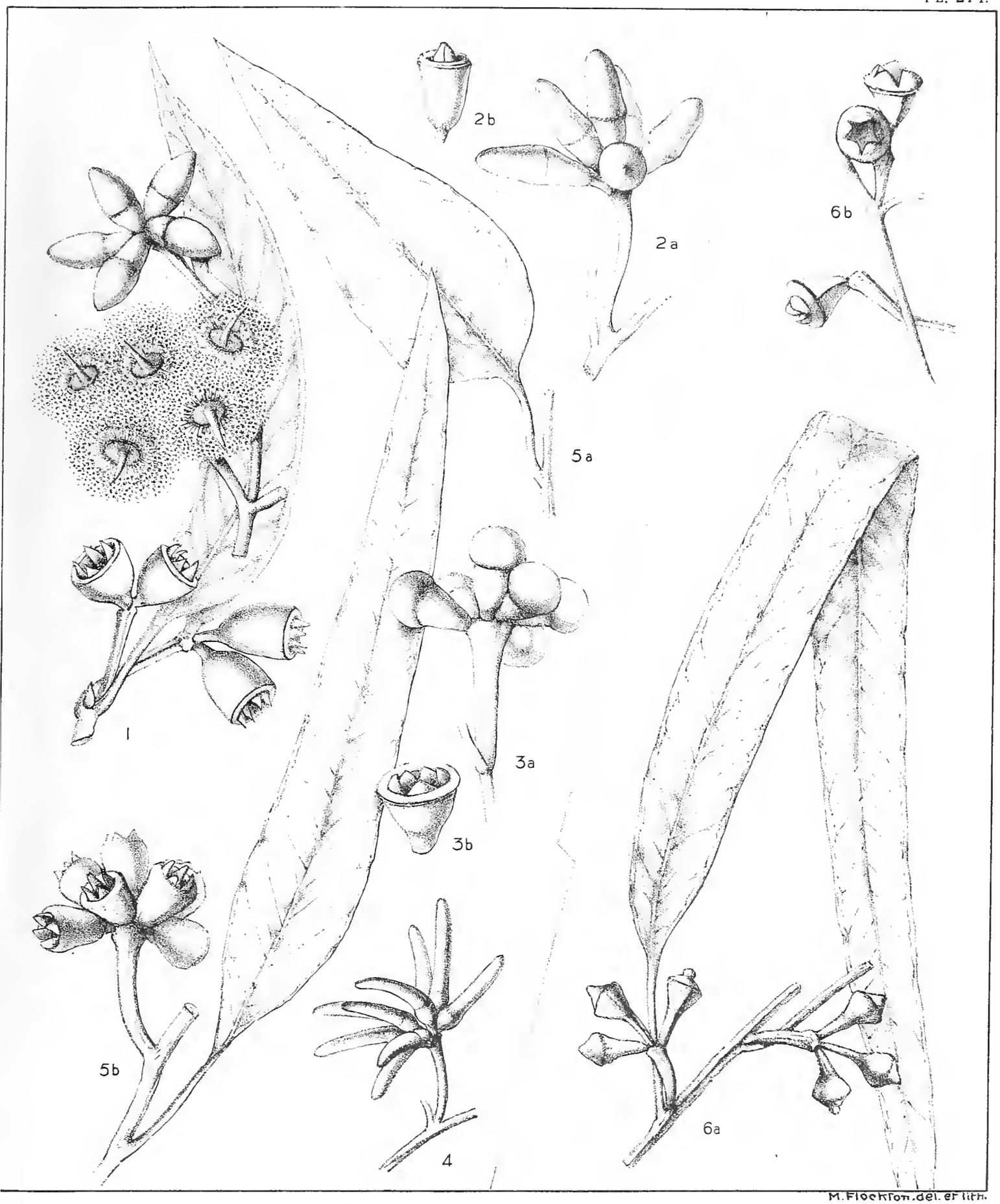
× EUCALYPTUS ALGERIENSIS TRABUT. (*1, 2*)

× E. ANTIPOLITENSIS TRABUT. (*3*)

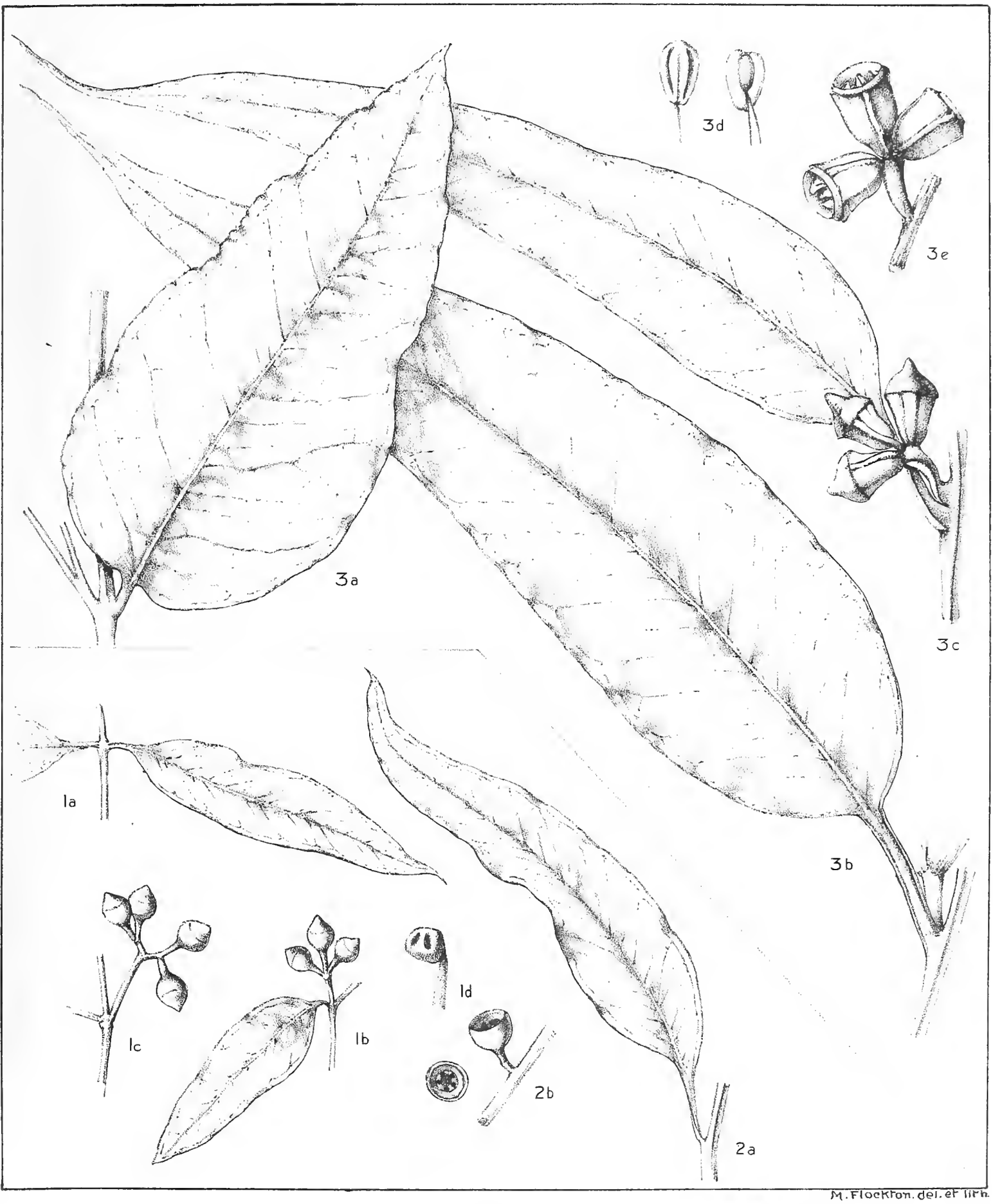
× E. BOURLIERI TRABUT. (*4, 5*)



x EUCALYPTUS CORDIERI TRABUT. (*1–3*)
x E. TRABUTI H. de VILMORIN. (*4–6*)



× EUCALYPTUS GOMPHOCORNUTA TRABUT. (*1–5*)
× E. PSEUDOGLOBULUS HORT. (*6*)



M. Flockton. del. et lith.

× EUCALPYTUS INSIZWAENSIS MAIDEN, n.sp. ~~(1-2)~~ (3)

× E. JUGALIS NAUDIN ~~(3)~~ (1-2)

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